SCIENCE IN THE ELEMENTARY SCHOOL

McGraw-Hill Series in Education

HAROLD BENJAMIN, *Consulting Editor*

AYARS · Administering the People's Schools
BARON AND BERNARD · Evaluation Techniques for Classroom Teachers
BEAUMONT AND MACOMBER · Psychological Factors in Education
BENT AND KRONENBERG · Principles of Secondary Education
BOGUE · The Community College
BROOM, DUNCAN, EMIG, AND STEUBER · Effective Reading Instruction
BROWNELL, GANS, AND MAROON · Public Relations in Education
BRUBACHER · A History of the Problems of Education
BRUBACHER · Modern Philosophies of Education
BUTLER AND WREN · The Teaching of Secondary Mathematics
BUTTERWORTH AND DAWSON · The Modern Rural School
BUTTS · A Cultural History of Western Education
CARTER AND MCGINNIS · Learning to Read
COOK AND COOK · Intergroup Education
COOK AND COOK · School Problems in Human Relations
COOK AND COOK · A Sociological Approach to Education
CROW AND CROW · Mental Hygiene
CROXTON · Science in the Elementary School
DAVIS · Educational Psychology
DAVIS AND NORRIS · Guidance Handbook for Teachers
DE BOER, KAULFERS, AND MILLER · Teaching Secondary English
DE YOUNG · Introduction to American Public Education
FEDDER · Guiding Homeroom and Club Activities
FERNALD · Remedial Techniques in Basic School Subjects
FOREST · Early Years at School
FRANDSEN · How Children Learn
GOOD · Dictionary of Education
GRUBER AND BEATTY · Secondary School Activities
HAGMAN · The Administration of American Public Schools
HAGMAN · Administration of Elementary Schools
HAMMOCK AND OWINGS · Supervising Instruction in Secondary Schools
HAMMONDS · Teaching Agriculture
HECK · The Education of Exceptional Children
HOPPOCK · Group Guidance
JORDAN · Measurement in Education
KEMPFER · Adult Education
MCKOWN AND ROBERTS · Audio-Visual Aids to Instruction
MCNERNEY · The Curriculum
MCNERNEY · Educational Supervision

MACOMBER · Teaching in the Modern Secondary School
MAYS · Essentials of Industrial Education
MAYS · Principles and Practices of Vocational Education
MELVIN · General Methods of Teaching
MEYER · An Educational History of the American People
MICHEELS AND KARNES · Measuring Educational Achievement
MICKELSON AND HANSEN · Elementary School Administration
MILLARD AND HUGGETT · An Introduction to Elementary Education
MORT AND REUSSER · Public School Finance
MORT AND ROSS · Principles of School Administration
MORT AND VINCENT · Introduction to American Education
MORT AND VINCENT · Modern Educational Practice
MOUSTAKAS · The Teacher and the Child
MURSELL · Development Teaching
MURSELL · Successful Teaching
MYERS · Principles and Techniques of Vocational Guidance
PITTENGER · Local Public School Administration
PRESCOTT · The Child in the Educative Process
REMMLEIN · The Law of Local Public School Administration
REMMLEIN · School Law
RICHEY · Planning for Teaching
SAMFORD AND COTTLE · Social Studies in the Secondary School
SCHORLING AND BATCHELDER · Student Teaching in Secondary Schools
SEARS · The Nature of the Administrative Process
SMITH, STANDLEY, AND HUGHES · Junior High School Education
SORENSEN · Psychology in Education
STRANG, MCCULLOUGH, AND TRAXLER · Problems in the Improvement of Reading
THUT AND GERBERICH · Foundations of Method for Secondary Schools
TIDYMAN AND BUTTERFIELD · Teaching the Language Arts
WEBER · Personnel Problems of School Administrators
WEBER AND WEBER · Fundamentals of Educational Leadership
WELLS · Elementary Science Education
WELLS · Secondary Science Education
WILSON, STONE, AND DALRYMPLE · Teaching the New Arithmetic
WINGO AND SCHORLING · Elementary-school Student Teaching
WINSLOW · The Integrated School Art Program
YOAKAM · Basal Reading Instruction

SCIENCE IN THE ELEMENTARY SCHOOL

Including an Activity Program

BY

W. C. CROXTON, PH.D.

McGRAW-HILL BOOK COMPANY, INC.

NEW YORK AND LONDON

1937

PRINTED IN THE UNITED STATES OF AMERICA

XIX

PREFACE

This book is intended for the use of elementary teachers and teachers in training. Many splendid publications for children have appeared recently in the science field, but there is great need of richly suggestive material for the use of teachers.

The book is an outgrowth of experience in directing student teaching, in cooperating with the supervisory staff of the Teachers College, and in conducting a course in the methods of science teaching for prospective teachers and teachers in service. The author desires to express his appreciation to the director and supervisory staff of the Riverview School of the State Teachers College and especially to Miss Agnes Brohaugh and Miss Nellie L. Walker for their cooperation.

The book is especially dedicated to those teachers who, handicapped by lack of adequate background training and experience in science and science education, are facing new duties with professional zeal.

W. C. CROXTON.

ST. CLOUD, MINNESOTA,
April, 1937.

CONTENTS

EDITOR'S INTRODUCTION

The truly modern elementary school is a far cry from its highly formalized predecessor of fifty years ago. The simple, nineteenth-century institution for imparting the rudiments of letters and numbers has become a center for rich provision of all the varied and complex experiences that children need and enjoy.

The distance between the old and the new elementary schools may well be measured in terms of the professionalization of their teachers. To impart the simple rudiments of literacy in a mechanical fashion, one needed only to be a pedagogical mechanic. To stimulate the widening of intellectual, social, and artistic interests among thirty children, all alike and all uniquely different in an ever-changing variety of ways, to cultivate the growth of their initiative, to develop their appreciations, to direct their creative efforts, to make them skillful in formulating and testing generalizations—these are tasks not for a mechanic but for an engineer of learning. The difference between these two levels of teaching is essentially the difference between rule-of-thumb practice and a practice based on the bedrock of comprehensive theory and classified experience.

Teaching can be a great craft, and the truly successful teacher is always a great craftsman. He knows that he cannot be completely practical without being completely theoretical, that practice is blind without theory, and theory vital only when based on the facts of experience. He knows that a great craftsman is not one who follows simple routines mechanically and without understanding but rather one who brings to his work a warm sympathy for his subjects, a full knowledge of his materials, a wide familiarity with methods and processes, a high level of skill in the use of tools and instruments, and a clear vision of distant goals.

In this book, Professor Croxton has written for the elementary teacher who wishes to be professional in the modern sense. For such a teacher he has provided a comprehensive and inspiring theoretical basis for the teaching of elementary science and a wealth of detailed source material for classroom use. His

theoretical presentation points the direction of the journey; his analysis of activities furnishes the vehicle in which to travel.

Teachers in service who desire to make science activities something more than mere additions to their crowded schedules will find here a book to lift their eyes far beyond the day's program and yet give them the practical day-by-day help necessary for effective teaching. Students in teachers colleges and schools of education who are preparing for elementary school work will find here both a textbook and a source book.

One unusual feature of this book deserves special mention. Not only has the author devoted an exceptionally large portion of Part I to a summary of research contributions, but he has also given extensive and valuable suggestions for needed researches in the field of elementary science teaching. Puzzled graduate students searching for topics to investigate will welcome the aid of this section.

The author has used the materials contained in this book with outstanding success in teaching courses in methods of science instruction for the elementary school and in supervising the work of teachers in that field. The publishers are glad to make these materials available for all prospective teachers and teachers in service who wish to direct science activities in the elementary school in a superior fashion.

HAROLD BENJAMIN.

PART I

SCIENCE IN THE ELEMENTARY PROGRAM

A BRIEF TEXTBOOK FOR ELEMENTARY TEACHERS

CHAPTER I

EDUCATION AS DEVELOPMENT THROUGH INTERACTION

The Teacher Needs a Professional Outlook

For some of us teaching is a profession; for others it is either skilled or unskilled labor according to the techniques employed. The distinction is largely whether or not we have acquired a broad guiding philosophy in the light of which we direct our trained efforts. An educational philosophy illuminates the needs of childhood and society so that we see the goals of education through and above the techniques and procedures of our profession. Without such an outlook, increased facilities and enriched curriculums are of little help to the teacher. A program of science activities becomes only an addition to the already overburdened routine of the schoolroom. The lack of a clearly visioned philosophy is probably responsible in large part for the mechanizing of much of our school work with consequent dulling of initiative and stultifying of curiosity. It is of the greatest importance that we give professional consideration to the basic philosophy that shall guide us in the determination of our aims and methods and in the selection of activities and subject matter.

Brief Statement of a Broad Educational Philosophy

The reduction of any philosophy to a few tenets is a difficult task. However, it seems advisable to attempt an embodiment of some of the major principles in a broad philosophy of the educational process.

1. Education is a developmental process concerned with the whole being.

2. The widening of interests and the cultivation of initiative do much to assure the contacts and interactions necessary to bring about this development.

3. These interactions produce slow changes in the individual's appreciations, attitudes, and habits of thought and action, together with a gradual growth in comprehension of the broader

generalizations of knowledge which offer the most intelligent basis for human guidance.

4. These major outcomes are best realized through a series of undertakings each of which constitutes a stimulating and satisfying experience.

5. The goal of education is the fullest realization of the possibilities of the individual not only for his personal welfare but for participation and contribution in a changing society.

The Relation of This Philosophy to Experimentation

It may be argued that this philosophy is not based upon experimental evidence. The answer is clear. We must admit that there are very few problems in education on which we have adequate experimental data to base procedures. Moreover, most of these studies have dealt with matters of technique and accomplishment in limited fields rather than with the broad problems of educational philosophy. As yet, we have not explored the human mind sufficiently to know how to assure its functioning along individually satisfying and socially valuable lines. Experimentation is a check and an eventual guide, but the broader outcomes of education and the program for their accomplishment will be as far in advance of their determination by research as educators can philosophically analyze and vision human welfare and progress. On the other hand, philosophy without research tends to become visionary.

Experimentation in education is much more complex than many persons seem to realize. We may discover an effective way to impart certain information, but we must admit a rather sorry failure in educating for individual and social needs. The implication, at least, is clear. There are more important factors in education than those which we have been able to measure. In our philosophy, which is to guide our teaching, we must incorporate, but not be limited to, the results of educational experimentation.

In addition to the complexity of the human mind and its behavior, there are other difficulties in experimentation in education and the social studies which are not experienced in the physical sciences and certain phases of the biological sciences, where experimental discovery seems to be revolutionizing existence. These difficulties are, in part, a matter of time and, in part, a matter of social change. The results of our experiments are

evidenced over a long period of years as the individual meets the personal and social problems of existence, and these problems will not be exactly the same for any two individuals. Interpretation of our experiments is further complicated by the fact that the entire situation is rapidly changing. The educational process and the experiments in education are conducted in a different social situation from that in which the final results are to be interpreted and judged.

The extreme complexity of the organization and behavior of human beings as compared with inorganic substances, the time required to determine the results of our experiments, and the rapidly changing social and economic structure render the experimental determination of a broad educational philosophy difficult in the extreme. These facts need neither entirely discourage us nor keep us from making use of experimental work in education. However, full realization of the difficulties involved ought to help us to interpret educational experimentation more sanely. Above all, it should convince every teacher of the need for broader outlooks in her profession. What a wonderful transformation could be effected in our schools, in spite of the limitations, if each teacher more clearly visualized the educational process and set about with professional understanding to promote educational growth. To this end, let us carefully study each of the principles in this philosophy as it affects our work as teachers of elementary science.

Further Consideration of This Philosophy

1. *Education Is a Developmental Process Concerned with the Whole Being.* We are concerned with the cultivation of the child as a whole and his self-expression, not merely with fact getting. Suppose that the child undertakes to rear a flower from a bulb. Let us consider the educational outcomes. He will learn something about bulbs and the conditions necessary for growth, but would anyone contend that this is the only, or even the most important, outcome of such a creative activity? The experience may open to him a new means of enjoying leisure time and an abiding and growing satisfaction. He may through the activity make a contribution to the home or school and grow thereby in the attitudes that make him a good member of a social group. The act may bring emotional satisfaction and contribute to

mental and physical health. The undertaking may serve as part of the foundational experience necessary to enable him to comprehend the concept that living things are dependent upon a suitable environment to attain their full inherent possibilities. The child may even be one of those to whom experiences in growing plants mean the discovery of an interesting life work. It is likely that this experience will act as an incentive to undertake another. This is a rich educational experience which develops the personality of the child as a whole and far transcends the learning of a few facts through telling, reading, or passively observing.

One may liken the preoccupation with fact getting to the procedure of exercising small muscle groups and developing local skills; as one may compare the execution of a creative act to the play of children, with their common ministry to the whole personality of the child, mental, physical, and social. This parallelism is closer than at first appears, for the distinction between creative acts of children and their play is hardly a real one. Indeed, in the hands of a professional teacher, they are indistinguishable. The child functions as a whole in these acts, and our practice of stressing only the fact-getting phase of a complete educational experience shows a lack of perspective indefensible in a broad educational philosophy. Education grows out of human experiences, and the more phases of his being the child brings into play in an educational act the more valuable will be the outcome.

Education is not mere aggregation. It is even more than the shaping effects of human and other environmental influences. It is rather to be regarded as change and development through interaction. While our knowledge of nerve action is far from complete, it is sufficient to reveal that education is a developmental process. It is true that the helpless infant possesses the units of the highly complex human nervous system. It is equally true that his receptor-adjuster mechanism is less ready for immediate effective use than that of other vertebrates. He is accordingly more helpless. More interactions are necessary before he gains control of even the simplest acts. But he possesses certain advantages. More interconnecting nerve paths are capable of development with consequent greater possibility of influencing reflexes and varying human responses. The potentialities of the central nervous system of a human being

with its millions of units, or neurones, are probably greater than has been realized and are at present unknown.

All of this renders educational practices absurd that treat the child as a storehouse into which knowledge is simply to be poured. It emphasizes the point of view that the individual educates himself through exercise of his rather undeveloped powers, but it in no wise minimizes the importance of the teacher. Rather it elevates her role to that of a profession, since books, phonographs, radios, and moving pictures can impart information. The professional teacher provides encouragement and opportunities for the functioning of latent powers, as does the physician who has come to realize that his most important role is providing favorable conditions for the restoration of the functioning of natural forces which bring health to the individual.

Contacts with his environment stimulate the child to exercise his undeveloped powers. A brief reaction or a profound interaction may take place. These interactions, during which the child is affected by his environment, and, in turn, as a result of the functioning of his nervous system, impresses his effects upon it, bring about change or development in him. All education probably takes place in this way, although some stimuli originate internally.

Some contacts may produce little interaction, while others result in numerous and varied forms of expression involving a large number of nerve units and coordinating glandular and muscular activities. Many of our assigned lessons and subsequent recitations probably produce only limited changes. Undertakings in which the child takes the initiative, and in which many of his latent powers find exercise in more complete forms of expression, probably have much greater developmental or educational value.

2. *The Widening of Interests and the Cultivation of Initiative Do Much to Assure the Contacts and Interactions Necessary to Bring About This Development.* Since education takes place through interactions of the individual with his environment, it is important that the child make a wide range of contacts and that these contacts be made in such a way as to call forth the exercise of the powers that we wish to develop. Elementary schooling has usually afforded few direct contacts. Out-of-school contacts are many and varied, but certain conditions essential to insure educational interaction are frequently lacking. Without the stimulus

and encouragement of an inspiring teacher, the complex influences of schoolmates and the atmosphere of achievement, advice in selecting suitable activities, books, materials, and just the right amount of help when needed, most of these environmental contacts fail to result in as rich educational experiences as it is possible for the schools to provide. While the school is only one of the educational agencies, it can best assume leadership in bringing about the interactions that make for development.

This requires that the elementary school do more than provide instruction in the tool subjects and the usual courses in the special fields of music, art, and physical education. It must provide for a wide range of contacts with the living and nonliving environment and must stimulate the child so that these contacts and those made out of school will result in more educating interactions. Merely instructing the child regarding his environment is insufficient. Rather, his contacts with the environment ought to lead him to explore, experience, and achieve—in other words, to undertake something educational. Such undertakings entered upon in this spirit offer great possibilities for rich educational interactions.

Perhaps the most wonderful outcome of doing a creative act is the desire to undertake another. The cultivation of initiative is of tremendous importance in education, since it leads into more and more educating experiences. Each undertaking involves new contacts and arouses new desires. Children whose training at home and in school has been of this nature tend to devise new games, make collections, tame and rear animals, grow plants, design doll clothes, construct, compose, paint, give plays, and engage in a great variety of creative acts during their leisure hours. Vacations tend to become more educational, especially when school fairs are held in the fall to encourage the carrying on of creative activities during the summer.

On the other hand, the methods of education traditionally employed in the schools do not seem to result in the same degree of initiative. The following quotation from the writings of Comenius (1592–1671) stresses this as one of the most needed reforms in the schools of that day.

> From this precept it follows that the proper education of the young does not consist in stuffing their heads with a mass of words, sentences, and ideas dragged together out of various authors but in opening their understanding to the outer world, so that a living stream may flow

from their own minds, just as leaves, flowers, and fruit spring from the buds on a tree, while in the following year a fresh bud is again formed, and a fresh shoot, with its leaves, flowers, and fruit, grows from it.

Terrible deviation in schools. Hitherto the schools have not taught their pupils to develop their minds like young trees from their own roots, but rather to deck themselves with branches plucked from other trees and like Aesop's crow, to adorn themselves with the feathers of other birds; they have taken no trouble to open the fountain of knowledge that is hidden in the scholars, but instead have watered them with water from other sources. That is to say, they have not shown them the objective world as it exists in itself, but only what this, that, or the other author has written or thought about this or that object, so that he is considered the most learned who best knows the contradictory opinions which many men have held about many things. The result is that most men possess no information but the quotations, sentences, and opinions that they have collected by rummaging about in various authors and thus piece their knowledge together like a patchwork quilt.[1]

This type of educational procedure is still surprisingly common, although for centuries occasional outstanding educators have pointed a better way. The progressive education movement in America today, whether it be regarded as a new movement or merely as the accentuation of a vital element in all good teaching, is largely a reaction against schooling of this nature. We find John Dewey, eminent and discerning educational philosopher, expressing the situation thus:

. . . In short, among the native activities of the young are some that work towards accommodation, assimilation, reproduction, and others that work toward exploration, discovery, and creation. But the weight of adult custom has been thrown upon retaining and strengthening tendencies toward conformity, and against those which make for variation and independence. The habits of the growing person are jealously kept within the limit of adult customs. The delightful originality of the child is tamed. Worship of institutions and personages themselves lacking in imaginative foresight, versatile observation and liberal thought is enforced. . . .

And yet the intimation never wholly deserts us that there is in the unformed activities of childhood and youth the possibilities of a better life for the community as well as for individuals here and there.[2]

[1] From Comenius; quoted in KEATINGS, M. W., "The Great Didactic of Comenius," London: Adams and Charles, 1896, pp. 299–300.

[2] Quoted from DEWEY, JOHN, "Human Nature and Conduct," by permission of Henry Holt & Company, New York, 1922.

This philosophy, in which the mind is considered a creative, developing organ and not simply a storehouse, has appeared in the thought of succeeding periods until it has exerted a profound effect, particularly on the education of young children. However, while a great deal of primary education is planned with this outcome in mind, it does not necessarily follow that all teachers are imbued with this philosophy. Their roles are frequently assumed in a more or less arbitrary manner and consist largely in carrying out procedures and employing techniques that they have been taught to use, with little vision of this supreme thing in education which we are attempting to develop.

The child is surrounded with opportunities to observe, to explore, to interact, and to interpret. This seeking habit of mind is essentially the initiative that we are trying to develop. It is the child's way of growth, and it is our ultimate hope for the solution of the growing, deep-seated, perplexing problems of our civilization. This habit of accepting the challenge to achieve and actively to inquire into the various phases of our environment seems as possible of attainment by most individuals as do the opposite mental habits of failure and passive acceptance without inquiry. Health, ability, opportunity for educational contacts, and information that provides new interests play important roles in developing initiative, but they do not insure the practice in achieving which is probably essential to its development. So far as we are able to discover—for like many of the other most important aspects of education it is difficult to measure—initiative seems to grow out of purposing and achieving. The child who has carried out a complete educative act is challenged by the doing. This change in his subsequent reactions, although difficult to measure or express mathematically, is often quite noticeable. An attitude of inner satisfaction, or self-expression and self-realization, pervades the child. He manifests a more active interest and presently may show up with another achievement. It may not be a wonderful product or discovery, but it is as dear to the truly professional teacher as is the sign of the patient's returning strength to the physician; for it shows more than an improvement in external manifestations—it is the growth of an inner force.

3. *These Interactions Produce Slow Changes in the Individual's Appreciations, Attitudes, and Habits of Thought and Action, Together with a Gradual Growth in Comprehension of the Broader*

Generalizations of Knowledge Which Afford the Most Intelligent Basis for Human Guidance. Project activities, well chosen, lead to a wide range of interactions with the environment. Where sufficient help is given to enable the child to overcome obstacles and achieve satisfaction, such a struggle environment seems exceptionally favorable for educational growth. At its best this growth seems to proceed somewhat as follows. Self-confidence, self-reliance, and initiative increase. Active interests and positive attitudes toward learning develop. Appreciations become more intelligent, and critical thinking is cultivated. Projects lead to others, and wider interests are manifested. The child encounters identical elements and principles again and again in various forms, and gradually some of the seeming chaos of his environment is reduced to order. He obtains glimpses of a world in which natural laws operate. When he finds that he can depend upon the operation of these laws, a feeling of assurance grows, and superstitions appeal less to him. As his social interests develop, he tends to examine our social and economic order in the same critical light. If his science education continues throughout his maturer years, he may become one of the small but rapidly increasing number of individuals who, having command of the broad generalizations of science, are able to view life from the vantage point of a scientific outlook.

These changes in the individual proceed slowly and result from an enormous number of interactions with the environment. That the teacher may comprehend the gradual nature of the educative process, let her pause at this point to recall some matter of morals, religion, professional philosophy, or scientific concept in which her outlook has altered. With this example in mind, let her try to determine the exact time at which the change in outlook took place. She will almost certainly find that the change has been a gradual one extending over a considerable period of time and has come about as the result of a large number of experiences. If she will attempt a brief mental survey of her present appreciations, attitudes, habits of thought, and concepts, recalling the changes that have taken place in each, the picture of her gradual education will be almost complete.

We might wonder whether these changes in the individual, which we call education, are the natural and inevitable outcomes of growth and development, rather than changes brought about by significant interactions with the environment. This possi-

bility practically disappears, however, when we consider the number of fairly capable persons who grow to physical maturity failing to manifest developed appreciations, attitudes, and mental habits and whose concepts of life are almost primitive. Even among the products of our schools this result is all too common. There are certain indications that these results might be different if the relatively passive methods of education were replaced by more virile interactions growing out of purposeful activities increasing in penetration, scope, and abstractness from the kindergarten through the college. The effects of more active methods in which the student purposes, plans, and exercises initiative and responsibility are strikingly evidenced in students returning to the teachers colleges after one or more years of teaching experience. They are also observable in the development produced by certain extracurricular activities—Scouting, Four-H Club projects, home laboratories, and other experiences—in which the child undertakes tasks that lead to educational interactions. While such agencies alter certain appreciations, attitudes, and habits of thought, they are limited in their range. They may not afford a basis for a broad outlook or even for intelligent action in many of the common matters of life.

There is need, therefore, for analyzing these appreciations, habits, attitudes, and broad generalizations which are the distillates of knowledge and for developing an extensive program of interactions which will result in these outcomes. Such a program must be rich enough to provide for selection on the bases of interest and opportunity. We cannot expect to provide experiences in the elementary school that will bring about all of these changes in the child, nor can we hope to achieve these results by waiting until maturity and presenting the desired outcomes as so many facts to be learned. These outcomes are the reward of the slow educational process at its best, of the interactions of the nervous system through an extremely long series of experiences, and the program cannot be set in action at too early an age.

4. *These Major Outcomes Are Best Realized through a Series of Undertakings, Each of Which Constitutes a Stimulating and Satisfying Experience.* To the person who has finally achieved something of a broader outlook, this eventual outcome may seem sufficient reason for the expenditure of all the energy necessary for its attainment. The young child, wholly unconscious of the

ultimate outcomes planned for him, possesses only immediate interests and desires. In general, the younger the child the more immediate must the satisfaction be. We may continue with a long series of lessons designed to develop eventually in him the desired outcomes, but the process is an unnatural one requiring a great many props to maintain it. On the other hand, if we interest him in accomplishing a suitable limited undertaking and make it possible for him to attain satisfaction, he will take the initiative and be more eager for new ventures. Even as adults we seem to need the stimulus of a definite undertaking and the satisfaction attending its completion.

Children ask questions about many things, but they seldom wish to know all at any one time. The attainment of immediate satisfactions is probably very important for normal development, and it is through numerous experiences, each of which constitutes a stimulating and satisfying experience, that the education of the child ideally takes place.

It is well here to attempt to interpret the nature study and elementary science movements, although such brief comparison cannot adequately represent either. The satisfaction of the child's immediate desires growing out of interests in his environment has always been uppermost in the nature study idea. Less consideration has been given to direction of effort toward comprehension of scientific concepts. On the other hand, the current elementary science movement, as embodied in the Thirty-first *Yearbook* of the National Society for the Study of Education,[1] presents a highly organized set of outcomes. Such outcomes possess great directional value. However, to attempt to teach these broader outlooks as so many lessons would show lack of comprehension of the educational philosophy involved. It requires an immense number of interactions to develop broad concepts, and through these experiences there is ample opportunity for the satisfaction of the child's immediate interests. Moreover, it seems likely that only through achieving such satisfactions can we ever rise to perspective concepts. Here, then, is the meeting place of the nature study and elementary science movements, which are really emphases on two phases of a well-rounded science program. The problem is one of providing

[1] Thirty-first *Yearbook* of the National Society for the Study of Education, Part I, "A Program of Science Teaching," Bloomington, Illinois: Public School Publishing Company, 1932.

experiences which satisfy the child's immediate needs, and through them of leading him into broader outlooks.

5. *The Goal of Education Is the Fullest Realization of the Possibilities of the Individual Not Only for His Personal Welfare but for Participation and Contribution in a Changing Society.* The reaction against an education concerned with the ability to recite facts has taken various forms. The child-centered school places emphasis on the development of the child's latent powers. We are also hearing much of the need for training which will fit the child for his social existence. To date, most of the efforts along this line have been on the assumption that our social and economic order is a fairly stable one and that we have only to simulate it in our schools and teach the child a high regard for it. It is becoming evident to all thinking teachers that this assumption is not based on fact. On the contrary, we are in a transition stage toward a society based less on the principle of exploitation. It is, moreover, evident that in our attempt to adjust the child to the old social order, we may even make him less able to cope with the new situations that will inevitably arise in a changing society.

What, then, is the best preparation for service in a rapidly changing society? The solution would seem to call for coordinated and simultaneous emphases in two directions. First, the child must be educated to expect and to meet new problems. Our hope of accomplishing this end lies in a project- and problem-solving type of education, in which the child is constantly finding his way in new situations and overcoming difficulties. But this type of training alone may develop more antisocial individualists bent on selfish achievement at the expense of other members of society. We must, therefore, educate for individual and cooperative action in the interests of the welfare of the group. While we cannot foresee the exact nature of the society toward which we are moving, it seems reasonably certain that it will have to be more social and less antagonistically individualistic. Accordingly, we must replace the stress on worshiping our present social organization as ideally perfect, with a program of educational activities carried out in the interest of the common good.

Elementary science can contribute to such a program of education in several ways. It is an especially favorable field for development of initiative through meeting and solving a wide range of problem situations in an activity program. Many of these

situations, as, for example, conservation, are of social as well as scientific significance. Moreover, elementary science offers a great many opportunities for learning to work together through cooperation in group activities. It also provides simple experiences contributing to the gradual comprehension of broad concepts which free the mind for wider social outlooks.

Problems Involved in Putting This Philosophy into Practice

This philosophy of science teaching is not new. In fact, it is often accepted in theory and disregarded in practice. If we accept the hypothesis that education proceeds through interaction and that well-chosen undertakings purposed and achieved bring about the development of the child as a whole, we cannot escape the obligation to make the necessary provisions for these experiences. Many arguments are advanced by persons who agree that this method of education is most desirable but consider it impractical. A brief consideration of some of these objections may serve to show that they are not so serious as they are commonly thought to be.

Teachers and administrators sometimes wonder what reaction the parents, who do not fully understand the teacher's aims, will make to such departures from cherished school routine. They fear that the children's activities will be considered a waste of school time which might be more profitably employed. Such fears are mostly exaggerated. When children are happy and enthusiastic in pursuit of their school work, the community can usually be depended upon to react favorably. Parents are gradually becoming accustomed to a changing school system and have already recognized the value of many recent additions to the program. Boys' and girls' club work has also done much to teach them the value of the child's creative efforts. An example of this changing attitude of the parents has recently come to the writer's attention. The patrons held a business meeting at a rural school in which a considerable amount of project work in science had been done. Instead of condemning the projects everywhere displayed about the schoolroom, the parents became so interested and enthusiastic that they remained for an hour and a half after the business meeting examining and discussing them. The county superintendent spent a much longer time than usual on his visit to this school and praised the work of the teacher in most glowing terms. The teacher commented on the fact that

the science projects, instead of detracting interest from the other subjects, seemed to have added spirit to all of the work of the school.

Another objection frequently advanced is concerned with individual differences. Some teachers feel that, while such a program of creative activities would be splendid for the brighter pupils, the slower ones would be entirely lost. Although adequate experimental evidence on this point is lacking, experience does not seem to bear out this contention. Every teacher has probably been surprised at times at the creative accomplishments of some children who do not fit well into the usual school routine. Some slow children seem to be motor minded and to require a great deal of concrete experience and interaction in order to comprehend. It is true that the more capable children will be likely to achieve more brilliant results by any method, but the slow pupil probably has greater opportunity for attaining satisfaction in project work than in any other way. In certain phases of group project work he may even excel. In individual undertakings he does creative acts which are sufficiently different from those performed by other children to afford the satisfaction of having contributed something. He is less subject to unfavorable comparisons and less prone to adopt the resigned attitude of inferiority.

The objection based on an overcrowded curriculum is a serious consideration in our schools. It is rather generally conceded, however, that elementary science merits an important place in the elementary-school program. Without minimizing the necessity for instruction in the tool subjects, we are coming to realize the importance of education that proceeds through interaction with the environment and leads to understanding and appreciation of it. The newer courses of study for the elementary school generally reflect this growing emphasis on elementary science in increased provision for science instruction. It is scarcely a question any longer as to whether more science instruction shall be provided but, rather, how it shall be done. In unified and integrated programs, science is an important component. In such institutions as the ungraded rural schools, where the crowded condition of the curriculum is most acute but where the opportunities for such instruction are unexcelled, much valuable work can be promoted extracurricularly. In the most progressive rural schools the problem is being solved by integration. In all

institutions some of the work will be done out of school hours, although a science period is important for coordinating the activities. Unless a definite period is allotted, there is a strong tendency to consider such work of minor importance and to neglect it under the stress of other scheduled duties. When the role of science in elementary education is better comprehended, there is little doubt but that room will be found for it in even the most crowded curriculums.

Many teachers who express preference for project work in science are so bound by the course of study that they do not feel free to use their initiative. Those who plan the courses of study have no desire to hamper the able teacher but only to supply information and guidance to those who have insufficient professional knowledge or ability to plan their work. There are few administrators or supervisors who will object if the work outlined in the course of study is centered about well-chosen activities. Moreover, few courses of study specify the method by which the facts and principles shall be taught. Most claims to the necessity for slavish adherence to the course of study are indicative of lack of the necessary professional knowledge to use it wisely.

A much more important difficulty, which a few teachers have regarded as almost insurmountable, is the problem of conducting an activity program in an overcrowded classroom and building. There can be no question but that this is a practical difficulty. With nearly all of the floor space in the room occupied by desks, an ideal arrangement for creative work is impossible. But if lack of space in the room should make it impossible to carry out certain undertakings, it is not a deciding factor in most activities. There is usually room for a few shelves on the wall, a small table or two, and window space for growing things. School desks are by no means useless in project work. Furthermore, a large part of the activities will be carried on out of doors. While school buildings are generally far from ideal for this type of education, it cannot be denied that some of the best work in the world has been done under rather unfavorable conditions. We cannot afford to await the construction of ideal buildings to launch an improved method of education. An excuse that is almost as frequently advanced for not carrying on an activity program in science is the lack of materials with which to work. That this objection is not insurmountable in the lower grades is evident. A group of primary teachers once offered the lack of materials as

the chief reason for not providing a virile program of science experiences. When these teachers analyzed science activity programs to determine the equipment and materials necessary to carry them out, these alleged difficulties largely disappeared. Most of the necessary materials were found to be readily obtainable at little or no cost.

The problem of dealing with a large number of children is a greater one for many teachers than is the lack of suitable space and equipment to carry on the work. The teacher admits that learning and reciting lessons is not of equal educational value with creative activities but finds the problem of dealing with forty children on any but a routine basis very difficult. If the number of children assigned to each teacher could be reduced, it would greatly simplify the problem; but prospects for relief in this direction are not very bright. For some time to come we must frequently work with large numbers. While this is possibly the greatest unavoidable obstacle, even it does not preclude the possibility of a program of activities in the elementary school. It does mean that many activities must be carried out as group projects which would otherwise be undertaken individually. It is also necessary that the teacher be given help in the form of suggestions for suitable activities. These suggestions should indicate the outcomes, show how the activities may be carried on, and furnish necessary information in time-saving form. Courses of study usually outline the field and aid in organizing the work to prevent needless repetition, but they seldom furnish the necessary suggestions for procedure and the information to enable the overworked teacher to guide the activities to fruitful conclusion. Success in directing an activity program with a large group of children also requires the development of suitable techniques. While these techniques must be perfected by practice, some practical suggestions will be found in the chapter on method.

Unquestionably one of the greatest problems involved in putting the philosophy embodied in this chapter into practice is the preparation of teachers. There can be no doubt that many teachers shy from such a program largely because they do not feel prepared to direct it. It is a perennial argument whether teachers are limited more by lack of academic knowledge or by lack of professional point of view. Both deficiencies are constantly met with, and both attainments are essential. In addi-

tion to an understanding philosophy, the teacher must have a wide range of interests, knowledge, and experiences in order to be able to promote the varied creative activities of children. It has been well stated that it requires a long time to obtain a cultural background and a relatively shorter period to develop a professional emphasis. The criticism has frequently been made of our teachers that they possess better techniques but far less cultural background than their European contemporaries. We have come to consider our education in terms of a certain number of courses in school, a given number of which prepare us to teach. So long as we follow a set curriculum and employ the traditional methods of teaching, this preparation more nearly suffices. We ask most of the questions and direct their trend. Few unexpected situations arise. Once, however, we depart from this accustomed routine and become directors of activity in a stimulating and advisory capacity, the need for more comprehensive knowledge and experience becomes painfully evident. New problems arise, and we are beseiged with questions about very simple matters which have somehow escaped our attention in scheduled courses. Interests, habits of observation, inquiry and interpretation, and a wide knowledge of the biological and physical environment are sorely needed.

The teacher who feels herself lacking in this phase of preparation for her profession will not be discouraged and routed from her purpose, however, if she is sufficiently grounded in the basic philosophy of education, although the temptation to settle into that easier and more comfortable procedure of hearing lessons proves irresistible to the hordes who lack this guide. If certain experiences are desired by the children and seem most suitable for them, she will saturate herself with these experiences and with the elementary knowledge involved in their interpretation. If the project involves an elementary knowledge of electricity, of plant growing or the identification of common objects new to her, she will seek experiences, sources, and persons able to teach her in these matters. What she failed to get during her training period she will acquire. This is not necessarily an adverse criticism of the content of her training courses, since such courses can serve only as introductions to the various fields and cannot prepare us for all of the later needs that may arise. We shall always be faced with the necessity of studying each new situation and obtaining needed information. Any teacher who is unwil-

ling to put forth the necessary effort to acquire the experience and information needed to direct a varied program of activities in a changing world and who insists on merely passing on what has been taught to her in the schools is unworthy of professional recognition.

It is likely that the teacher will have most reason to regret that her training was not of a nature to develop in her the initiative and habits of attacking a new situation which she, with deeper insight into the educational process, is trying to develop in her pupils. This lack is indeed important and regrettable but not unsurmountable, for it is a part of the teacher's philosophy that education is a process that continues throughout life. The undertakings of adults are much like the creative acts of children, involving purposing and surmounting difficulties, with the development of power and initiative as important outcomes. Each creative act undertaken by the pupils becomes likewise an undertaking for the teacher, who frequently must first accomplish the task for herself and who must always visualize the outcomes and explore the related fields of knowledge. In this manner the teacher, placed in a struggle environment, grows in power and initiative. Each year is not like the last. The struggle continues, but it is full of interest and adventure. No teacher with a far-reaching educational philosophy can count the cost too great, for through her growth in initiative, in wealth of knowledge and experience, she is learning to do more than earn a living—she is learning to live a life. And it is in this way, as she intermingles and becomes absorbed in her environment, that she becomes an interesting and cultured individual.

CHAPTER II

THE PLACE OF SCIENCE IN THE ELEMENTARY SCHOOL

Development of Science As an Elementary-school Subject

The present period is one of reorganization in elementary science. In order to understand this reorganization and the place that science is coming to hold in the educational program, it is necessary to know it as a growing study rooted in certain fundamental movements.

The fascinating history of science teaching cannot be adequately retold here within a single topic. To do it justice, it would be necessary to include much of the history of education. But this history should be familiar to all teachers who recall the philosophies and contributions of such familiar figures as Comenius, Rousseau, Herbart, Pestalozzi, and Froebel. Better to understand the growth of our field, it would be well for the teacher to read a good history of science and an exposition of the nature philosophy, such as Bailey's "The Nature Study Idea," to supplement the necessarily inadequate account that follows. Through the pages of these books she will thrill with the founders and builders of science teaching over a new spirit in education.

The early history of elementary education in America is the story of the struggle for public free elementary schools. It was almost the middle of the last century before even the most rudimentary training in reading, writing, spelling, and arithmetic was made available to all children through the public schools. Perhaps it would hearten some of us, when we become discouraged with the reactionary elements in our school communities, to read again the difficulties encountered in the struggle of nearly two hundred years' duration which resulted in the meager training afforded by the early public schools.[1] It was a great step forward in education that all children should have the opportunity to

[1] It is interesting to note that the struggle has not yet been entirely won and that the forces that opposed the inception of free public education are, in the main, the same ones that oppose its extension today.

learn to read and write. But the training was exceedingly limited, and the methods employed were traditional, the teacher's duties consisting largely of hearing children recite from books. In many places a monitor system was practiced, and one teacher had charge of a large number of pupils.

By the time that the public elementary schools were underway, Pestalozzian influence had begun to make itself felt in America. The most influential of these earlier transplantations of Pestalozzian methods to America was in the schools of Oswego, New York. For the recitation of lessons from books, it largely substituted oral instruction based on sense perceptions of objects. Thus arose the object lessons about which much of the educational controversy of the nineteenth century was waged. The Oswego movement became widely known and spread to many schools. The object lessons possessed the advantage of directness, and they tended to replace the rather mechanical memory method with the use of the various senses in acquiring knowledge. In some instances the object lessons were highly systematized and were regarded as natural science, or at least a preparation for science, which was "completely classified knowledge." About 1870, Superintendent Harris introduced natural science into the schools of Saint Louis. It was a highly formalized type of science stressing the classification of "nature inorganic" and "nature organic." The object lessons were being criticized on the ground that they were disconnected and taught isolated facts not organized into any comprehensive whole. Natural science placed emphasis on mastering scientific classification and terminology.

It was soon after this that Agassiz opened his history-making Penikese School in an old abandoned barn on an island in Buzzard's Bay. The barn was both living quarters and laboratory for the group of enthusiastic workers as well as a shelter for the birds that flew in and out unhindered. Out of Agassiz' school went many of the men who became pioneers in the science movement in colleges and academies. Fortunately among his students were a few who carried this inspiration into the teacher-training institutions and the elementary schools.

One of these pioneers was Henry H. Straight, who, after studying with Agassiz in 1873 and 1874 and afterward at Cornell and Harvard universities, became professor of natural science in the Oswego Normal School in 1876. He had previously aroused much interest in science at the State Normal School at

Peru, Nebraska. At Oswego he outgrew in his thinking the disconnected object-lesson method in vogue there. For the object lessons he strove to substitute the study of things in their interrelationships. Later at the Cook County Normal School he further developed the nature study idea and turned to the correlation of subjects as a means of unifying and interrelating educational experience.

While much credit is due to Straight, there are many evidences that the transition from the object lessons to the more vital nature study viewpoint was a natural trend and growth. During this period Henry L. Clapp and Arthur C. Boyden were active in a similar movement in Massachusetts. The inadequacy of the object lessons gradually became evident to a number of educators. Thus was born the nature study movement. While retaining the direct approach based on sense perception which represented the greatest contribution of the object lessons, the nature study movement placed emphasis on the child's attitude toward his environment. The aim most often advanced for nature study was "to open the pupil's mind by direct observation to a knowledge and love of the common things in the child's environment."

The nature study movement gained headway during the period from 1884 to 1890. In Boston, in the State Normal School at Oswego, New York, the Cook County Normal School in Illinois, the State Normal School at Bridgewater, Massachusetts, and the schools of Plymouth County it developed[1] almost simultaneously. Among the pioneers of the movement were H. H. Straight, Alpheus Hyath, Lucretia Crocker, Wilbur S. Jackman, Frank Owen Payne, and Arthur C. Boyden. Under Jackman the subject first attained a recognized rank along with other subjects in the Cook County Normal School in 1889. His "Nature Study for Common Schools" appeared in book form in 1891. He visualized nature study as an important element in the curriculum and did more, perhaps, than any other individual to establish it as such. Many of his views were not greatly different from those of leaders in the elementary science field today. He believed in a wide range of experiences with nature's activities rather than a detailed study of a few lifeless forms. The phenom-

[1] For a highly interesting and informative brief account of this development read The Nature Study and Elementary Science Movement by Florence Weller and Otis W. Caldwell in *School Science and Mathematics*, 33: 730–740, October, 1933.

ena attending the change of seasons, his "Rolling Year," constituted his nature study course. He would have the children study these phenomena as they meet them, rather than in a logical order determined by their scientific relationships. However, in his outlines and in his teaching, Jackman's work, like that of most of our own, seems to have been a compromise between his philosophy and the prevailing practices of his day.

Cornell University took up the work as a distinct enterprise in 1893 and assumed leadership in many ways. There labored distinguished teachers, Liberty Hyde Bailey and Anna Botsford Comstock, whose writings at least are familiar to all elementary teachers. From this center came the *Nature Study Leaflets* which are still being issued and which hold an unquestioned place as one of the best teaching helps available in the elementary field.

By the end of the nineteenth century the nature study movement had spread to a large number of schools in many states and had become an important factor in the changing point of view of elementary education. During the early part of the present century the subject attained a place in school programs rather generally, and many will attest to its stimulating influence in their lives. But despite the brilliant work of its leaders, the subject has not fulfilled the hopes of educators in the majority of our schools. In many systems it became incidental, little more than a name.

The success of the movement has been limited by certain factors. It requires a stimulating teacher in close and sympathetic touch with the environment, a professional requirement which has been met in only exceptional cases. A host of nature books appeared, but many were written by persons lacking scientific knowledge. Much of the fanciful and the teleological crept into nature writing and teaching. In many cases nature teaching degenerated to, or failed to rise above, mere naming of objects with little of the sympathetic interest in activities and the understanding which moved its more ardent devotees.

Within the nature study movement there have always been two diverging and frequently conflicting points of view. Guyer, in the *Nature Study Review*, expressed the opposing viewpoints thus:

It would appear that at least two distinct ideas are masking under the name of nature study. The first verges on the sentimental. Its

aim is to waken in the child the proper emotional attitude toward nature. It has in mind the child's feelings and sympathies. The other regards more the child's intellect, the necessity of training him to observe accurately and to think clearly.[1]

Perhaps the fact that nature study evolved from the reaction against the isolated object lessons and against the "dry-as-dust" science teaching explains the extreme emphasis that many of its advocates have placed on the development of desirable attitudes toward the environment, largely to the exclusion of other values. Even a man of such wide interests as Liberty Hyde Bailey sounded this note above all others: "Nature study is not science. It is not knowledge. It is not facts. It is spirit. It is concerned with the child's outlook on the world."[2] The limitations as well as the contribution of this type of nature study are evident in such statements as the foregoing. In its insistence upon divorcement from science lies, perhaps, the fundamental weakness of the nature study movement.

There have always been those who saw in nature study a broad science program leading to understanding of natural laws as well as to desirable interests and attitudes. This view is evident in Jackman's statement of aims and is discernible in much of the literature of the nature study movement. There is within it the seed of the best in science teaching, though the seed has not always been recognizable in the product. Some will regard the present elementary science movement as a resurgence and further development of the nature study movement in its more comprehensive aspects. There is much truth in this view. There has now been time to evaluate the nature study movement and to integrate it in a more comprehensive educational philosophy. It is to be hoped that a historical perspective may help us to keep a better balance in the new movement.

It is especially interesting to compare the criticisms directed at the object teaching fifty years ago with some of the current criticisms of the nature study movement. It will be recalled that the "lessons on objects" were criticized on the basis "that they were disconnected and that the knowledge resulting from them was a knowledge of isolated facts not organized into a

[1] Quoted from Weller, Florence E., and Otis W. Caldwell, The Nature Study and Elementary Science Movement, *School Science and Mathematics*, 33: 739, October, 1933.

[2] Bailey, L. H., "The Nature Study Idea," Garden City, New York: Doubleday, Doran & Company, Inc., 1906.

comprehensive whole."[1] In the *Yearbook*[2] of the National Society for the Study of Education for 1932, under the heading "Commonly Accepted Principles of Nature Study," appeared a criticism beginning as follows:

> There is in these "accepted principles" an emphasis on facts, with an exclusion of principles; an emphasis on nature study for discipline, with no clarification of the meaning of discipline; and an effort to draw a distinction between child and adult psychology.

The criticism points out that a satisfactory organization of learning experiences to accomplish definite desired outcomes, which was one of the chief defects of the object lessons fifty years ago, has not been achieved through the nature study movement.

It is interesting and important to note that both the object lessons and the later nature study movement originated and developed in the elementary schools and teacher-training institutions. The point of view and the contribution of the movement have been the pronounced emphasis on the child and his development through direct and sympathetic contacts with his environment. Science education workers generally will agree that this is a vital standpoint and an element that must not become obscured or lost in the new movement. The nature study movement made a very valuable contribution in directing attention to the need of bringing the child into direct sympathetic relationship with his environment to the end of life enrichment. This remains one of the major aims of the elementary science program.

During this time, however, a great body of scientific knowledge has developed. A complex and bewildering civilization has replaced a simpler one. While it is based upon relatively few scientific concepts and generalizations, applied science together with economic and social forces have compounded out of them a most confusing array of devices, activities, potentialities, dangers, and human problems. Science education has lagged far behind scientific achievement and its epoch-making influences. A new

[1] Criticism by Dr. Piez of the Oswego, New York, Normal School reprinted in Bailey's "The Nature Study Idea."

[2] Quoted by permission of the society from the Thirty-first *Yearbook* of the National Society for the Study of Education, Part I, "A Program of Science Teaching" p. 17.

movement is on in education. Elementary science must play its part. Sympathetic interest in nature and a will to understand its manifestations alone are insufficient. We must have these valuable forces directed toward more clearly defined ends.

In order to understand the current movement in elementary science we must turn briefly to the other trend in science teaching which did not originate in the elementary school as did nature study but, rather, has lately spread to it. This is the systematized science-teaching movement which spread from the colleges and academies to the high schools, into the junior high-school years, and is now influencing content and practice in the intermediate and primary grades. Until recent years, emphasis in college and secondary-school science was largely on the subject matter as a body of classified knowledge to be studied, rather than upon the pupil and his needs. Content and method were rather highly formalized. About twenty-five years ago, the general science movement began to develop in the ninth grade and later in the seventh and eighth. With it has come a freer educational experimentation and a much greater consideration of pupil needs. One of the greatest contributions of the current phase of this movement is a much more critical evaluation and selection of subject matter in terms of life situations. As the movement grew, it became evident that many phases of the junior high-school science course concern children in the intermediate and even in the primary grades. Accordingly, we have witnessed the progressive simplification of many of these units for use down through the elementary school.

These two more or less well-defined movements, nature study and systematized science teaching, which are meeting now in determining elementary science are not so far apart today as they were a few decades ago. It must not be inferred from this meager account that the nature study of recent years contained nothing of science. Likewise, the science-teaching movement in the junior high school and the elementary school has rightly departed from the attempt to teach the child a logically organized body of science materials without consideration of their pertinence to him. It seems desirable that we no longer emphasize distinctions between the two movements but preserve the contributions of both. Both movements have emphasized vital elements which must be incorporated in our science in the elementary school if it is to meet the needs.

A realization of the great problem facing the teacher in an age of science is dawning upon us. Even senior high-school and college teaching are changing under the impact of this realization. Science teaching is to furnish a large part of the fundamental educational basis for intelligent existence, but it is even more. It is a method—a way of life. We have only begun to align educational forces to meet the need. The realization is growing that we must build a science program extending from preschool age throughout life if the need is to be met.

The first consideration is our aims. All workers are agreed that facts are not to be regarded as our aims but rather as means to further ends. Some of the major objectives that are to determine our work probably have their roots in the systematized science teaching. Others have been fostered to a greater extent by the nature study movement. Among the former are the attainment of broader outlooks based on the generalizations of science, the development of scientific attitudes and methods of procedure, and the ability to utilize the findings of science for health, safety, and achievement. Among the last are the finding of new avenues of interest and satisfaction and the development of certain desirable social attitudes and appreciations. Other attitudes and appreciations are clearly products of both movements. Strictly speaking, the development of no one of the major outcomes[1] is entirely attributable to either movement alone.

The second consideration is that the general experiences and procedures planned for the new curriculum shall be such as to accomplish these major outcomes. Here, again, by its insistence upon analysis of major objectives to determine the elements essential to their comprehension and upon use of the scientific method (although actually it is not generally used in science teaching), the systematized science movement offers a valuable contribution. At the same time the influence of the nature study movement, with its emphasis on satisfying the desires growing out of the child's immediate interests, will help to keep the work within the pupil's world, to make it a course in science rather than about science, and to lend directness to the approach. Certainly broad concepts cannot be taught to children as such but must be achieved through a very large number of well-planned, challeng-

[1] For a further account of the major objectives see the chapter entitled "Aims in Science Teaching."

ing experiences. Although leaders in science education have tried to make this clear, there is considerable likelihood that teachers poorly versed in the philosophy of the movement may attempt to teach these ultimate outcomes as so many lessons to be learned.

Present Status of Elementary Science

Now that we have some acquaintance with the history of elementary science and with the best elements of nature study and science teaching as they are entering into the philosophy of the new movement, let us examine the present status of the subject in the schools. As might be expected by anyone familiar with its history, there is no generally accepted course in elementary science. Here and there in the schools one may find some stage of the history of the subject reenacted. Occasionally one finds nature study at its best, as in some of the rural schools of New York State and in a few cities, but more often an incipient or perhaps a decadent form of it. In a few elementary schools,[1] but much more commonly in the upper grades and high schools, more than a vestige of the highly systematized science which prevailed in the colleges and academies is in evidence.

In some schools the subject is little more than a name. It does not appear on the daily program, although the traditional differentiated subjects have been retained, and some new titles added. This is often the case even where time is allotted for elementary science instruction by the state course of study. When asked the reason, teachers and supervisors usually state that there is not time for it. They frequently add that they correlate it with reading and other subjects when they can. Many teachers frankly state that they are not familiar with science materials and do not know how to proceed. Since the appearance of the many attractive science readers in recent years, more attention is being given to the subject. It is finding a regular place on many more school programs, although perhaps more as a reading course than one of direct experiencing. Teachers feel that they can conduct the work in the science readers. Administrators and supervisors realize that their schools are wanting in this field and are ready to include science in the school

[1] Elementary school as used here extends only through the sixth grade. In the seventh and eighth grades of both graded and ungraded schools an attempt is usually made to teach science.

program when they see tangible teaching helps that seem to give promise that the subject will take its place along with other organized branches of elementary learning.

This brief discussion can hardly express the diversity that exists in the elementary science field. In a few schools the work is carried on largely through science clubs. In a number of schools teachers are attempting with varying degrees of understanding to direct a science-activity program. In some rural schools recently visited by the author, the walls, shelves, cupboards, hall, and even the floor displayed the results of children's project activities. The attitudes of the children and the general atmosphere of the school indicated that the science teaching was at least opening new avenues of interest and satisfaction. While purposeful work is being carried on in many places, in very few schools is there a comprehensive program looking toward accomplishment of the major aims of science teaching.

In certain cities, and particularly in experimental schools, it is evident from the published reports that these criticisms do not apply. Teachers are being trained in service; elementary science is receiving deserved emphasis; and contributions are being made. In some states where there has been a strongly organized elementary science movement, conditions are probably better than here described. Little evidence exists, however, that there is adequate conception of the aims of science teaching and effective organization of the work to accomplish them. Mann's studies of the amount of time allotted to various subjects in 444 city systems in 1926 showed about 1 per cent of the total time given over to "nature study and elementary science."[1] One is forced to conclude that the status of elementary science in the schools is far from satisfactory. This status is clear to most teachers, although many of them are not fully aware of the roles that the subject should play in education. In too many schools there is not even a serious effort to develop a virile course. In many systems the condition is probably similar to that which maintained in the Cleveland schools prior to the origin of the elementary science center in the Doan School. Anna E. Burgess,[2] principal of the Doan School, described the condition thus:

[1] MANN, C. H., "How Schools Use Their Time," Contributions to Education, No. 333, New York: Teachers College, Columbia University, 1928.

[2] BURGESS, ANNA E., The Curriculum School As a Method of Building a Course of Study in Elementary Science, *Science Education*, 18: 4, pp. 216–221, December 1934.

Elementary science as a part of the curriculum had almost a virgin field in which to work. Except here and there where a teacher was especially interested in the out-of-doors, even the teaching of nature study had faded out of the daily program. As to the physical sciences, they were considered the field of the high schools.

A program of well-selected experiences leading to generally accepted major outcomes is an ideal that has not been attained in our schools. It represents a plan and a basis for experimentation and development, rather than a state of achievement. Only a very limited amount of research[1] in elementary science education has been done. In a number of places, hopeful work in the development of an elementary science program is in progress. A number of greatly improved courses of study have appeared within the past few years. But for the most part, leaders in the field have been engaged in redefining our aims. If we reach even a tentative agreement as to our objectives in teaching elementary science, it will facilitate the determination of the content and procedure.

However, this does not adequately portray the present status of elementary science. An elementary science movement is in progress, although it is only beginning to find expression in the public schools. The evidences are unmistakable. Educational periodicals are devoting much space to the subject. Many elementary science readers and textbooks are appearing and are finding ready sale at a time when purchase of most schoolbooks is restricted. Marked revisions of courses of study are giving the subject a more prominent place in the school program. Some of the recently published courses of study in elementary science constitute sizable books and evidence a great amount of progress. Additional evidence of the movement is to be seen in the number of higher institutions offering courses in the teaching of science in the elementary school.

These evidences show very clearly that the movement to make science an important part of the elementary-school program of studies is getting under way. The appearance of new courses of study, methods courses, and elementary science textbooks indicates that the movement has already gained the momentum necessary to sweep away the traditional resistance of the schools against change. Already in a number of widely separated cities,

[1] Experimental and other contributions to elementary science teaching will be reviewed briefly in another chapter.

the science curriculum in the elementary school is receiving major consideration.

It would appear that we are entering the stage of the movement in which it will reach the children through reorganized school experiences. The rate at which this step in the movement will progress depends largely upon the training of teachers. Professional training seldom anticipates a need. Professional courses are organized as a result of demand arising out of felt needs. With the advent of new courses of study in science comes the criticism that institutions engaged in the training of teachers do not prepare for the job. There is much justification for this criticism.

In two important respects teachers are unprepared to direct elementary science work. In the first place, they do not possess the degree of understanding of the aims and philosophy of the movement essential to intelligent and sympathetic participation. Translating a philosophy into a working program and making a course of study operative under actual school conditions involves many problems and difficulties. It requires zealous efforts and even sacrifices which only those teachers are prepared to make who feel that they are vital agencies in an important reconstruction.

The majority of elementary teachers are unprepared in another respect. Most of them have had little training in science. The courses they have had in high school and college have not, as a rule, been of a nature to acquaint them with elementary science materials. This lack of acquaintance with the materials that the teacher must utilize is an important limiting factor. The additional effort necessary to carry on a purposeful science-activity program without an adequate background of training is only one of the handicaps that this lack entails. Perhaps even more important is the feeling of strangeness and helplessness which deters so many teachers from launching forth on a new venture. Rather than expose our inadequacies, we tend to shy away from situations that would be likely to involve and display them. It is doubtful whether anyone except the teacher herself, the science supervisor, and the instructor in the teaching of science is fully aware of how little the average elementary teacher knows about even her immediate environment. It would be interesting to know what percentage of teachers in elementary schools are familiar with the trees on the schoolground, to say nothing of the birds, insects, soils, rocks, and other common things of the

environment. It is true that teachers are inadequately trained in most fields, but the situation is much more extreme in elementary science. We are expecting teachers who are unfamiliar with the materials of science to plan experiences with these materials which will lead children into new avenues of enjoyment, develop desirable appreciations and attitudes, solve many of their immediate problems, and lead to ultimate concepts and generalizations.

Facing the situation fairly, and attempting to depict the present status accurately, we must conclude that teachers are not ready for the new duties thrust upon them. This will retard the establishment of elementary science as a virile subject, but changes are already in progress which may largely take care of the situation. In a large number of systems, teachers are being trained in service as new needs arise. Much can be accomplished with teachers who are still adaptable. It is interesting to note that adaptability is not always a characteristic of youth. Some teachers now in service probably never will do good work in science. There are some advantages to offset a few of the disadvantages in the rapid turnover in the profession, especially during important periods of transition. Each year many thousands of new teachers are entering the profession, and there is reason to hope that they will be much more adequately trained. While the requirements for certification of elementary teachers have gradually risen, they have always been lamentably low. The time is at hand when no less than four years of training beyond the high school in a professional institution will be acceptable. Combined with selective admission and more guidance, this increased training should accomplish much. But the greatest hope of better prepared teachers lies in the curricular changes now in progress in the professional institutions for the training of teachers. These changes are discussed in the chapter "Preparing to Teach Elementary Science." Let it suffice here to state that teacher-training institutions are not merely lengthening the period of training but are undergoing much needed redirection.

Role of Science in the Elementary Program

As we have seen, science has been an incidental, and at best a minor, subject in the elementary school. Despite our frequent references to the "three R's" as denoting the schools of a past age, the more essentially tool subjects are still the virtual core of

most elementary programs. The result of this emphasis, refined by a number of well-known researches, has been to render these educational aids much more effective. The improvement in reading alone is striking to anyone who was familiar with elementary education a quarter century ago. Despite adverse criticisms by uninformed persons, the elementary school probably affords a much better training in the tools for acquiring an education than did the schools of the past.

If we regard mastery of the elementary tools for obtaining a literate education to be the function of the elementary school, then it is doing its work passably well. That this is, and must remain, an important function of the elementary school no educator questions. But our conception of the role of elementary education and its relationship to the work of other divisions of the school has changed. The elementary school is no longer to be regarded merely as a place where we perfect the tools for obtaining an education at a later period. This point of view of the elementary school has been based, in part, on the erroneous assumption that children cannot reason until they are more mature and, in part, on a too limited conception of education. The apparently more acceptable view that children are limited in their reasoning primarily by lack of basic experiences rather than lack of the general ability to reason has revolutionary implications for the elementary school. It implies that a great function of the elementary school is to provide foundational contacts and experiences. It suggests that reading should be an aid in establishing wider contacts and in enriching their meaning; that the program should be built around direct experiences, not around reading.

What are the fields of contact and experience to which we should begin to introduce the child even long before he learns to read, and to which he will continue to devote his attention throughout life? They are the fields of (1) social contacts and relationships and (2) contacts and relationships with objects and natural forces. The former is the province of the social studies. Elementary science is the most fertile subject for exploration of the latter field in the lower grades. It is one of the great areas of elementary education.

The Organization of Elementary Science Instruction

Ideally, all instruction should be centered about the child's activities as his interests manifest themselves. As John Dewey

has stated, the earliest school training should grow out of, and be a continuation of, the experiences in the home. The school is a social institution, an important part of the child's world. In this environment he should carry on many social activities as his interests develop. These activities create the need and mind set for learning.

To many educators this implies an integrated program, rather than separate fields of study. Too many separate categories in the lower grades are not conducive to social activity and natural growth. They probably tend to disperse rather than integrate and to arrest the child's natural development. The present trend is distinctly toward organizing instruction in the kindergarten and lower grades in the form of activity units. In carrying out these activities, science, language, art, music, physical education, handwork, and simple mathematical procedures are employed as they are needed. Because such a large part of the active interests of children involve exploring the natural and the scientifically derived environment, elementary science is one of the chief elements in such an integrated program. This form of organization is probably to be approved, especially in the earliest grades. It should not be confused with the incidental teaching of science which is advocated for all grades by some persons who would keep the traditional subjects and correlate science with them. While all of us gain a worth-while part of our education incidentally, organization of instruction on an incidental basis has not proved satisfactory. Certainly elementary science as an incidental subject has made little progress.

There are several reasons why a definite science period is needed, except where a well-planned, integrated program is organized. This need exists regardless of the methods employed. Even where the work is of the nature of informal activities, a scheduled period is necessary to coordinate and direct the efforts. Unless definite provision is made for elementary science in the daily program, the work is likely to be neglected. Teachers regard the scheduled subjects as obligations, and there is little, if any, time or energy to devote to any incidental duties, however important. Moreover, scheduled subjects of instruction call for preparation for teaching them which would not otherwise be included in the teacher-training program.

The amount of time devoted to science instruction varies considerably among schools. The usual practice seems to be

to allot fewer hours per week to the study of science in the intermediate grades than in the junior high school and still less time in the primary grades. It is doubtful whether there is any sound reason for this practice other than that it represents a compromise by curriculum makers in the exigency of a subject entering a preoccupied elementary program. It is likely that it is also partly due to persistence of the concept of science as a study primarily suited to the maturer years. There seems to be excellent reason why equally as much attention should be directed to training in science during the period of childhood when the child is extending his range of interests and contacts as during junior high-school years when adolescent social interests have become more engrossing. When traditional opposition to science in the elementary school abates, it is likely that this important component of child training and experience will occupy a prominent place in the daily program.

Throughout this discussion it has been assumed that science will be taught by the classroom teacher. In many schools, employing a special teacher of elementary science would not even be considered. Wherever a specialist in science teaching can be employed, it may be better that he devote his time to building up the science program and aiding all teachers than to attempt to be a special teacher of science. A relatively few schools are organized on the departmental plan at the intermediate-grade level. Such schools should be able to secure teachers better prepared in science. In the ungraded and smaller graded schools, and in the overwhelming majority of all elementary schools, science teaching will be one of the duties of the general teacher.

Organization of the science curriculum for the elementary levels is a problem toward the solution of which only a beginning has been made. However, it is a matter of such great importance that a chapter will be devoted to a discussion of science in our changing elementary curriculum.

CHAPTER III

AIMS IN SCIENCE TEACHING

Failure of Elementary Science Teaching to Accomplish Worthy Aims

In spite of the fact that science exerts an almost overwhelming influence in our lives, elementary education has taken little notice of it. Children are growing up to play new roles without understanding. They are not introduced to science as a way of life and to its concepts as the basis for social thought and action but only to its external manifestations. The obligation of the schools to bring to the masses the greatest of all the contributions of science—a method of thought and approach—is not being realized. If we consider other desired outcomes of education in science at the elementary level, we find little more cause for satisfaction. Few avenues of interest in the environment are being opened to the children through the schools. Certainly little effective training is given in conservation, which might offset the increased destruction of natural resources resulting directly and indirectly from invention.

Paramount Importance of Clarifying and Vitalizing Our Aims

It is difficult to exaggerate the importance of clarifying our aims and developing professional zeal to accomplish them. The widespread lack of a clearly defined purpose in teaching is appalling. To verify this statement one needs only to begin to ask teachers, "Why do you teach this?" and "Why do you carry on your work in this manner?" The first answer usually concerns the learning of some information. Pressed further as to why children should learn the particular bit of information, the teacher is at a loss to offer any definite reason. She may advance some very generalized aim which embodies a hope to tax the credulity of even the most ardent believer in the transfer of training, or she may be able only to inform you that it is in the course of study. This is an unfortunate situation constituting one of the greatest causes for lack of effectiveness of our schools today.

It is not unreasonable to ask why, with our general courses in education and our special method courses, aims do not become the great goals that thrill the teacher with the hope of service, and toward which she bends every professional effort. Is it because the aims of education have not been made vital to teachers? Have we failed to make them stand out from the great mass of factual learnings in our professional schools as anything more than items to be memorized and recorded in examinations? Aims have embellished the opening pages of syllabi and textbooks only to be largely forgotten in the succeeding pages. Like the blessing once got out of the way at the start of a meal, we then deal with an orderly array of items with our consideration entirely divorced from the prelude. Somehow such great purpose must be given to our teaching in science and the social studies that the teacher reluctantly and with difficulty decides what valuable experiences are a little less vital and, therefore, can best be spared. Aims belong not in the general preface but in every separate undertaking, giving it zest and purpose and determining the selection of contributing learnings and methods to be employed.

We cannot stop at glibly reciting the general aims of education. Neither can we longer credit science education with accomplishing a host of abstruse ends. If our science program in the schools is to be effective, we must know definitely what we are trying to accomplish and must set about directly to achieve it. One can hardly comprehend the aims in the elementary grades without understanding the aims of the whole science program. Let us, therefore, turn our attention to what we are trying to accomplish through science teaching in general, after which we shall consider the contribution of science in the lower grades.

Major Aims in Teaching Science

1. To cultivate scientific attitudes and methods of procedure.
2. To lead to broader concepts, generalizations, and outlooks.
3. To open new avenues of interest and satisfaction.
4. To enable the individual to meet the problems of existence with the available scientific knowledge and requisite skills.
5. To develop social attitudes and appreciations.

In the preceding statement of desired outcomes there may be some apparent overlapping, although each is a distinct aim. It may be argued, for example, that if the child finds enjoyment

in wild life, he will act socially to conserve it. Yet many persons find a form of enjoyment in hunting and fishing without any apparent interest in conservation. Likewise, it might be assumed that one who proceeds in a scientific manner will obtain the needed scientific information and achieve a broad outlook, but obviously this is not so. It seems best, therefore, to keep each of these objectives before us and to plan activities that will lead to their realization. Let us carefully consider these aims.

1. *To Cultivate Scientific Attitudes and Methods of Procedure.* There is a tendency to confuse this aim with an attempt to make scientific specialists of our pupils. This confusion shows lack of understanding of the greatest contribution of science and of science education, which is clearly the dependence upon conclusions carefully arrived at on the basis of the evidence, rather than upon hearsay, propaganda, and tradition. This habit of mind is of the greatest importance to every individual in the ordinary problems of life. The reactions of persons all about us furnish innumerable examples of the need of this training. The unquestioning following of traditional procedures, the blind faith in miraculous cures, the acceptance of printed statements though they be contrary to the individual's repeatedly tested experiences, the tendency to accept and repeat as truth that which is pure hearsay and gossip, the willingness to accept the statements of others in matters that can easily be verified, the failure to distinguish between methods of arriving at "truth," and the prejudiced and closed-minded attitude toward new ideas constitute abundant evidence that this aim is not being achieved.

There is nothing vague about this aim. It is one of the very definite goals toward which our science instruction at all levels should be directed. What is desired is a sensitive curiosity; a habit of seeking the evidence, considering it carefully and withholding judgment until the conclusion is evident; a critical mind which is not easily swayed but is always open to additional evidence and new outlooks. The following statements prepared by Curtis[1] summarize the desired scientific attitudes:

I. Conviction of universal basic cause and effect relations, rendering untenable

[1] Quoted by permission from CURTIS, F. D., "Some Values Derived from Extensive Reading in General Science," Contributions to Education No. 163, p. 48, New York: Teachers College, Columbia University, 1924.

a. Superstitious beliefs in general, as "signs" of "good luck" or "bad luck," and charms;
b. "Unexplainable mysteries;"
c. "Beats-all" attitude, commonly revealed by
   1. Too ready credulity;
   2. Tendency to magnify the importance of coincidence.

II. Sensitive curiosity concerning reasons for happenings, coupled with ideals
   a. Of careful and accurate observation or of equally careful and accurate use of pertinent data previously collected by others;
   b. Of patient collecting of data;
   c. Of persistence in the search for adequate explanation.

III. Habit of delayed response, holding views tentatively for suitable reflection (varying with the matter in hand).
   a. To permit adequate consideration of possible options;
   b. To permit a conscious plan of attack clearly looking forward to a prediction of the probable outcome or solution.

IV. Habit of weighing evidence with respect to its
   a. Pertinence;
   b. Soundness;
   c. Adequacy.

V. Respect for another's point of view, and open mindedness and willingness to be convinced by evidence.

It has frequently been pointed out that instruction in other fields can contribute to this habit of mind, but science instruction offers a particularly favorable opportunity for its development. It can never be achieved, however, by blind acceptance of the statement of the teacher or of the printed page but only by affording practice in the method of thought and procedure that we wish to become habitual. The fact that these attitudes are somewhat specific calls for practicing them in a wide variety of situations. It is scarcely necessary to plan activities for the special purpose of training children in scientific attitudes and habits of thought. Rather, they should be one of the important aims in each undertaking. The accomplishment of this aim depends primarily upon the employment of suitable methods and will be discussed further in the next chapter.

2. *To Lead to Broader Concepts, Generalizations, and Outlooks.* Much of man's existence has been guided by superstition. A great deal of the primitive persists in our philosophy of life. More rational concepts based on the findings of science are very slowly permeating our thought. The slowness of their spread

does not seem especially strange when we consider how little opportunity most individuals have ever had of a nature to lead to their comprehension. Yet no other knowledge has greater possibilities for human guidance than the broader generalizations and outlooks growing out of scientific principles.

If our teaching of science is to result in the achievement of this aim, it is important that teachers keep these broad generalizations in mind and plan experiences through which pupils may be able to comprehend them. The following list of concepts borrows heavily from the "Principles and Generalizations Suggested by the Committee as Valuable for Guidance in the Selection of Specific Objectives" which appeared in the Thirty-first *Yearbook* of the National Society for the Study of Education and from the previous work of Craig. Certain statements in the *Yearbook* have been quoted; others changed more or less in scope; some omitted; and some additions have been made. The author wishes to credit the Yearbook Committee but assumes full responsibility for errors and limitations in the revised list. There is considerable difficulty in deciding what constitutes a broad concept, and it is not likely that there will be absolute agreement on any list. This does not prevent a suggested list from being useful. It is to be hoped that through a more extended cooperative effort on the part of educators and scientists in the various fields a more comprehensive and useful list can be obtained.

Broad Concepts Growing Out of Scientific Knowledge

1. Man's outlook, always limited by incomplete knowledge, is widened by discovery.

2.* Hypotheses and theories serve to stimulate and direct the search for truth.

3.* The scientific method is simply a careful, orderly procedure for arriving at truth.

4.* "Man's conception of truth changes."

5.* Energy is the basic entity, manifesting itself in many forms and forces which are interchangeable.

6.* The great diversity in form and behavior of matter, from its simplest form to its highest manifestation in organisms possessing consciousness and memory, is due to differences in the component charges which make up its atoms and to differences in degree of organization into innumerable chemical combinations and physical systems.

7.* An enormous amount of change and activity results from the absorption and release of energy through chemical and physical changes.

8.* In large-scale phenomena change proceeds in an orderly fashion from cause to effect according to laws which are discoverable, leaving no reasonable room for determination by chance or for superstitious belief.

9.* The duration of time is beyond our present powers of comprehension.

10.* The universe is vast.

11.* The movements of cosmic bodies determine most of the regularly recurring phenomena that we observe and render them predictable.

12.* The sun largely determines conditions on the earth, variations in its radiant energy producing changes which have profound effects.

13.* While no generally applicable distinction is known to exist between the animate and inanimate, and while it is probable that life developed from the less complex systems of matter not regarded as alive, it has evolved in the course of a long period of time into a great variety of forms.

14.* Life is maintained in the highly organized protoplasm through a complex of finely adjusted physiological processes which tend to be self-regulatory within limits, though great deviations from optimum conditions for functioning result in impaired health or death.

15. The higher plants and animals are entities through coordination of specialized units of life.

16. Continued existence on the earth is made possible through cycles involving recurring synthesis and decomposition.

17.* Natural forces bring about continual evolution of the earth and the conditions for existence.

18.* Asexual reproduction perpetuates existing forms of life; sexual reproduction involves reassortment and recombination of characters introducing an element of change in the stream of life which, together with the results of mutation, may within limits be directed toward the ends that we desire.

19.* Forms of life tend to survive which change in ways that prove suited to the conditions for existence.

20. Man represents a species that has persisted and gained a degree of control over his environment through development of a more highly organized central nervous system.

21.* "Through interdependence of species and the struggle for existence, a balance tends to be maintained among the many forms of life."

22.* The realization of the inherent possibilities of each living thing is dependent upon a complex of environmental factors.

23. The interactions of plants and animals with their environment tend to bring about succession toward relatively stable climax communities.

24. The enormous use made of the relatively small number of basic truths that have been discovered demonstrates the importance of research.

Many of these concepts are entirely beyond the comprehension of children, and they would be worse than useless if an attempt were made to teach them as generalizations in the grades. But concepts grow out of experiences which yield meaning, and some of them are founded on experiences quite common to even young children. Questions asked by children show a tendency to interpret these experiences. The interpretations may fall far short of the broad generalizations, but they are a necessary step toward comprehending them. In a well-planned program, principles and ultimately broader generalizations develop naturally out of a wealth of contributing experiences. Thus the science work of the grades, without employing premature forcing methods, can be made to contribute to the aim of achieving broader concepts and wider outlooks. But, while the process is not to be forced, it should be carried on with understanding of the role of immediate learning in the development of eventual outcomes. Otherwise, in this respect the activities lack direction and are essentially miscellaneous. In practice, this means that the teacher who understands this aim will direct many activities of value in the gradual development of intelligent outlooks, but it decidedly does not mean that she will preach these concepts as abstract statements before the child is able to comprehend them.

3. *To Open New Avenues of Interest and Satisfaction.* There are two reasons for opening new avenues of interest. New interests not only lead to educating interactions, but they provide

* Context wholly or in part similar to generalizations in Craig's list.

ways of self-entertainment and satisfaction. Training that will enable individuals to find engrossing interests has always been important. Recent changes have intensified this need. The increase in number of free hours due to labor-saving devices and to economic adjustments calls for more education for leisure. The extensive shift from rural to urban existence took large numbers of families from their intimate contacts with woods, fields, and streams, with their domestic and wild plant and animal life, and placed them in industrial surroundings. The gap in their lives thus created has been partially filled, since better means of transportation have become common, by wholesale trips "back to nature." There is a veritable week-end exodus from the cities. The roads are thronged with people hurrying away to more natural surroundings. This throng of nature visitors is largely composed of persons who are strangers to her ways. Although nature has for them the appeal of novelty, they are oblivious to all but the crudest and the most generalized interests. The superficial and even destructive reactions of these hordes in environments so full of possibilities for finding absorbing nature interests are sufficient evidence of the need for opening additional avenues of interest and satisfaction.

Still more fundamental than the need for interests to enrich leisure hours is the role of enjoyment and satisfaction in normal development. Whatever may be the advantages of confining children in school buildings during a large part of each year, these are too often offset through substituting indirect knowledge for the direct experiences which bring enjoyment and deep satisfactions. Instead of cutting the child off from opportunities to find avenues of interest and satisfaction, the school ought to be the agency that opens the gateways to new engrossing fields of activity. Science offers a wonderful opportunity for developing rich and varied interests. To engage children absorbingly in growing a few plants, rearing animals, observing and exploring, collecting, experimenting, reading, and writing their experiences is to open to them avenues of interest and satisfaction which lead farther into the realm of self-realization than the teacher can vision. Through opening these and many other avenues to the child, we do much to insure normal development, to provide for leisure time, and to bring individuals into more understanding and appreciative realtionships with their environment upon which enduring satisfactions rest. This aim is of first importance in the

elementary grades and should be kept constantly in mind in selecting and planning activities. Viewed in the light of the aims of science education, such activities are not to be considered as unimportant temporary amusement but as short journeys with the children into the interesting world about us until they are attracted by the phenomena of nature to further explorations.

4. *To Enable the Individual to Meet the Problems of Existence with the Available Scientific Knowledge and Requisite Skills.* Surrounded by the achievements of a scientific age, with existence growing ever more complex, the child has great need of training in the understanding and intelligent use of these new acquisitions The amount of directly helpful knowledge to be acquired is very great and is increasing rapidly. This information concerns most of the ordinary affairs of life.

Much of it has to do with maintaining health. We must extricate from the confusion of health lore and science the principles that are important for health and make them operative through habits, ideals, and understanding. Training for safety has become almost equally important. Accidents have become one of our greatest problems. An individual living to the age of sixty years under present conditions would stand an even chance of escape or injury by automobile accident alone. The total for all causes of accident is appalling.

Many of the ways of doing things in the past are becoming obsolete. New processes and devices for economy and increased achievement are available. Many of the products offered for sale are merely cumbersome trappings, which enrich only the advertiser, and a few are positively dangerous; but some are of great value in freeing human energy for intellectual and social existence. Facts and principles underlying these devices for work and pleasure are a worth-while part of science instruction.

There are many other phases of scientific knowledge of direct value in meeting life situations. Man does not hold the unquestioned supremacy on earth with which the unscientific mind is wont to credit him. He needs to know a great deal about the other forms of life which attack his crops, his domestic animals, his products, and even his own life, as well as the ways of utilizing the forms able to render him aid. His existence calls for understanding of the principles that govern plant and animal growth, the effects of environment, the means of improving life, and much other knowledge of practical value.

It is essential that the principles underlying this practical information be understood if we are to use our new heritage wisely and not be victimized by it. The wonders achieved by science have resulted in blind credulity on the part of many persons who lack the guidance that understanding of the principles involved would provide. Unscrupulous advertisers on every hand are taking advantage of this ignorance.

School training to provide knowledge and experiences of direct value in coping with the forces of nature and in making use of the fruits of discovery and invention should begin down in the earliest grades with matters of direct concern to the child. These include not only health and safety but many of the devices and processes that he is beginning to employ.

5. *To Develop Social Attitudes and Appreciations.* It is possible that some will object to declaring social attitudes and appreciations an aim in science teaching, on the indisputable ground that science is impersonal and is concerned only with discovering truth. Scientific study and research must not be subordinated or diverted by any ends, however desirable they may appear. This freedom is the most vital thing in the contribution of science. But once a law or principle is established by pure science, it may be used either to further individual ends at the expense of society or for the common good. We are coming to realize that education must be directed toward social outcomes. Many of the principles of science have important application to the public welfare. So long as we adhere strictly to scientific truth, there can hardly be any reasonable objection to the direction of science training toward cooperative action in the interests of society. It is true that this is, in part, the purpose of education in the social sciences, but the fields of instruction are not separate and unrelated. It is our duty to contribute to this social aim wherever possible.

When we look about at the consequences of the unfortunate direction of much of our scientific knowledge during the period of industrial development, we are forced to recognize the need for developing social attitudes and appreciations. Stream pollution has become a great public menace. The change of water levels has affected the welfare of numerous forms of wild life and countless people. There remains but a small area of the valuable forests of the country, while fires have increased until there is no adequate reproduction. The progress of what we have called civilization has left few natural remnants

of primitive America. Belated efforts are being made to set aside some of the few remaining areas. Many species of wood birds, game birds, and large aquatic birds are disappearing. Many of the larger mammals are almost extinct throughout a great part of the country and are holding their own in only a few areas where wise conservation methods are being practiced. We lament the depletion of many kinds of wild flowers, yet few people (including teachers) know which species their states are attempting to protect, and fewer still are able to recognize them. Our soils are still being eroded and depleted by unnecessary leaching and unintelligent management, despite the progress of soil science. We are using in the period of a few hundred years the mineral and other stores which are irreplaceable or are the product of long geologic ages. The lack of individual responsibility for social welfare is evidenced in the alarming accident statistics. Disease is still too largely considered a personal matter.

These and other similar situations exist today, and there is no adequate program to meet them. Attempts to remedy these conditions and to institute forward-looking policies are meeting with very limited success with a public not trained to utilize knowledge for social action. Despite the urgent need, there is no adequate public education in social attitudes and appreciations. Nothing short of a program throughout the schools directed toward this end can hope to accomplish this important objective. While scientific research must remain impersonal, public school education in science, as in all other subjects, must be directed toward social ends.

Aims of Science Teaching in the Elementary School

Having considered the general aims of science teaching, we come now to a more direct consideration of the aims of science work in the elementary school. Toward which of the major aims can science work in these grades contribute? The answer is that it should contribute to all of them but that to some of them the contribution will be greater and more direct than to others.

Foremost during this period let us place the opening of avenues of interest and satisfaction. These avenues lead to experiences with many phases of the environment and to interests in many

things. A miscellaneous partial list taken from the analysis of the activities in the latter part of this book includes school building, equipment, school grounds, street fixtures, trees, wild flowers, garden flowers, bulbs, vegetables, seeds, fruits, field crops, insects, birds, bird havens, wild animals, homes, domestic animals, pets, human activities, tracks, babies, friends, foes, foods, clothing, seasonal changes, daily changes, sun, wind, rain, snow, ice, sky, weather records, weathervane, boats and floating objects, brook, pond, sounds, touch, stones, nature trails, wood, rubber, glass, metals, permanent magnets, compass, batteries, electric circuits, electromagnets, wind wheels, water wheels, steam turbines, whistles, stream valleys, gliders, airplanes, out-door cookery, museum, aquariums, terrariums, winter sports, time, directions, and soils.

But no list of the objects and phases of the environment in which we hope to interest the child, however comprehensive it may be, can adequately express this aim. We must show the child new things to do with these objects, ways of finding absorbing interest and satisfaction. Then we must go with him, keeping ever in the background, far enough along each of these avenues ot satisfaction so that he will continue to tread them. Who among us is not limited because some one failed to initiate us into some of the joys of living? Some of these avenues to be opened and trod with the children in elementary grades are:

Observing birds, mammals, insects, and other animals, machines, construction work, seasonal changes, weather, night sky, etc.

Exploring ponds, streams, parks, fields, meadows, woods, greenhouses, streets, roadsides, rock exposures and gravel pits, industries (within limits of safety).

Growing house plants, garden flowers, wild flowers—(from seeds), shrubs, tree seedlings, vegetables, fruits, water plants.

Rearing toads and frogs, insects, injured or deserted birds, aquarium fishes, snakes, turtles, baby chicks, rabbits, other mammal pets.

Collecting stones, leaves, fruits, seeds, wood samples, insects, curios, stamps.

Constructing birdhouses, feeding stations, fountains, toy boats and rafts, kites, rearing pens and insect cages, models of airplanes and other devices, toy airplanes and gliders,

wind wheels, water wheels, steam turbines, and many other devices.

Experimenting with permanent magnets, electromagnets, compass, simple electrical circuits, mechanic sets, power hook-ups with small electric motor, boats, toy wind wheels and water wheels, kites, seed dispersal, whistles, conditions for plant growth, animal intelligence and habits, food preferences of birds and other animals.

Keeping weather records, nature calendars, diaries, scrapbooks, sketching, photographing, writing brief accounts for the local paper.

Reading science magazines, lives of great discoverers, elementary books on many phases of science.

It is not too early to begin the development of scientific attitudes and habits of procedure. Young children have a seemingly insatiable curiosity. This is one of the most essential scientific attitudes. Instead of stifling it, we must cultivate it. The child's interest possesses a freshness undulled by adult custom, coercion, and the substitution of much reading and reciting for direct experiencing.

We have come to consider the first few years of the child's life the most important formative period. It is possible that we may discover that they are likewise most important in establishing scientific attitudes. Our aim should be to have elementary pupils who are alert to the things going on about them and curious about many things, who ask questions, challenge statements, wish to try things out for themselves, demand evidence and reasons, check exaggerations, distinguish between the true and the "make believe" in stories, have a tendency to collect the evidence on both sides of a question before deciding, are open minded and able to change opinions, but are not too easily swayed by their associates. Lastly, children should realize that our knowledge is very limited and should experience great joy in discovery. This seems like a big order; yet if we choose suitable methods of procedure, we shall do much toward accomplishing this aim. The opposite attitudes of indifference, avoidance of disturbing and conflicting views, passiveness, blind acceptance and followership, overcredulity, superstition, fear, and closed mindedness have not become established in the young child. Our efforts are, therefore, more hopeful than in later years.

The elementary school is likewise the time to develop social attitudes and appreciations that have not already been inculcated

during preschool years. These desired social outcomes are concerned with many matters. Important among them are the practices that make for health and safety of others in school, home, and street. Cooperation is to be developed through group activities. This is also the time to foster desirable attitudes toward wild flowers, trees, birds, toads, snakes, harmless insects, and pets, if the frequently observed antisocial acts in dealing with these forms of life are to be prevented. Much of the destruction of public property by children might be prevented through understanding of the work involved in its construction, our joint ownership of it, and its need to be in order if it is to serve us. This attitude of group responsibility should be extended to preventing fires, guarding lawns, preserving machinery, and many other matters. The social attitudes also concern the happiness of others and, in the upper intermediate grades, a host of other matters, such as the cooperative control of insects and weeds, prevention of stream pollution, and the conservation of many things. It is extremely important to develop normal attitudes toward sex and reproduction before adolescent stresses and problems manifest themselves. Although it has received little attention in our schools, the development of social attitudes and appreciation is no less important than other aims.

Another of the major aims of science teaching is to enable the individual to meet the problems of existence with the available scientific knowledge. Certain of these matters of direct utility concern the elementary-school child. He needs certain habits and knowledge for preserving his health. He must be trained in various practices to insure his safety. As he comes to perform various acts, he should have the knowledge and experience to enable him to do so effectively, as, for example, in growing plants, caring for a pet, and constructing the objects he needs. He also needs to be able to use certain devices effectively. As early as the kindergarten or first grade, children have need to be able to give their names and addresses and to tell time and direction. Intermediate-grade children purchase many objects. Consequently, it is time to begin consumer education.

Broad concepts are the outcomes of wide knowledge and experience and, hence, are matters of slow growth. For this reason, and because of the difficulty of comprehension, they cannot be fully grasped in the elementary grades. Many experiences contributing to the ultimate comprehension of broad concepts are,

however, an important part of science work at this level. Broad concepts should be important unifying factors in education. The teacher of science in the elementary grades is contributing to the eventual concept outcomes some of their basic building materials in the form of experiences, facts, and principles. The concepts toward which the elementary activities in science contribute have been pointed out under the heading "Aims," in the analyses of activities which constitute the latter half of this book. The children will come to glimpse some of the concepts in an elementary way, but that process need not be forced. The important thing is that the teacher shall vision these concepts as important ultimate aims and build toward them.

CHAPTER IV

THE IMPORTANCE OF METHOD

The Basis for the Choice of Method

Method is of vast importance, as it largely determines the reactions and experiences of the pupils. By method we mean general procedure, not the refinements of technique which are sometimes used to dress up relatively poor procedures and make them appear professional. This confusion of minor techniques with major procedures has been as unfortunate in education as in medicine where the physician's manner and polished tools have often been accepted as evidence of professional understanding and ability in diagnosis and treatment.

Our general procedure is determined by what we are trying to accomplish. When we are able to measure the child's growth in scientific attitudes, broad concepts, avenues of interest, use of scientific knowledge in meeting his problems, and social attitudes and appreciations, it may be possible to determine the best methods to employ. Until such time as we may be able to effect such measurement, our guiding philosophy and our aims must largely determine our general method. To base the choice of method on the measurement of certain factual learnings is virtually to lose sight of the aims in science teaching.

Providing for Rich Interaction

Let us first see what light our philosophy throws on the problem of method. If education is achieved through the interaction of the child with his environment, as discussed in Chap. I, the first requirement for a good method is that it shall provide abundantly for such interaction. The essentially minor matters of technique, which frequently receive most of the attention in methods courses and in teaching practice, become relatively unimportant in comparison with the procedure of guiding the activities that bring the child into fruitful interaction with the environment and the problems of existence. Education of the child is not simply a matter of passing on to him the information that we, through our

interactions, have gained. There probably is a time in the education of the individual when he has had sufficient experience to be able to appropriate large amounts of information otherwise than through a series of undertakings which create favorable learning situations involving need and desire for knowledge, but that time is much later than the elementary period. No course about science is sufficient for children. The all-too-common method of basing the course on science readers, using materials only to illustrate, does not afford the necessary opportunities for interaction, although such readers are useful in a well-planned program of interactions.

Method in the Light of Our Aims

It is important also to consider method in terms of our definite aims. The best training for the use of the scientific method in meeting the problems of life is to employ it throughout the science course. Much doubt has been cast in recent years on the likelihood of remote transfer, and the need has been stressed for training in the matters and practices useful in meeting life situations. The life of an active-minded individual consists to a large extent of a series of undertakings—some small, some great. These undertakings involve desire or recognition of need, purposing, planning, executing, judging, and often perfecting. How similar is the procedure employed by the child in a well-planned school project or creative act, and how dissimilar the mere reading and recitation of information. Surely, from the viewpoint of the aim to help the child appreciate and use the scientific method in meeting the problems of life, there is a tremendous difference between these two procedures. To accomplish this aim best through the science course it would seem that (1) as much of the work should be in the form of undertakings or pupil enterprises as possible; (2) the child should learn to employ the scientific method in these undertakings; and (3) so far as the interests and powers of childhood permit, these undertakings should be selected with reference to knowledge, attitudes, and experiences useful in other life situations.

To accomplish the aim of opening new avenues of interest and satisfaction in the environment, stimulating contacts and interactions with its various phases are virtually essential. Who is not familiar with the active and satisfying interests

developed through intimate observations of birds, rearing insects, or stocking an aquarium? A well-planned program of science enterprises not only provides immediate satisfactions and learning situations but, in addition, opens new avenues for enjoyment and education during leisure hours. Such activities frequently develop into lifelong interests which add much to the enrichment of human satisfaction. These experiences not only yield direct satisfactions; but, indirectly through providing a background for reading, travel, and art, they make for happiness. It must be apparent to anyone who observes the masses of people rather blindly seeking satisfaction that relatively little has been done to open to them the possible avenues of interest.

The desire to conserve seems to be the product of a combination of experiences and knowledge, but it seems to be developed best in children through certain interactions which make for appreciation. Children who have followed the rearing of a bird family, built bird boxes, fed the birds and observed their food habits, kept migration records, and carried out other suitable bird projects are almost never promiscuous destroyers of bird life. In like manner, through such activities as wild-flower surveys, protecting wild flowers until they form seeds, and growing wild flowers from seeds, children come to appreciate and conserve wild flowers in their haunts instead of picking bouquets which frequently wither before they are taken home. Similarly, satisfying interactions with snakes, toads, mammals, trees, and other living things engender attitudes that make for appreciation and conservation. There is little question that knowledge also plays an important role in conservation and that much of the ruthless destruction is due to ignorance. Methods are needed that bring the child into appreciative and understanding relationships with the things that need to be conserved. Teachers have learned from experience that recitation of assigned lessons does not insure the practice of sanitary measures to prevent communication of disease, the development of desirable attitudes toward sex, and other equally important social outcomes.

Information of direct value in coping with the forces of nature and in making use of the fruits of discovery and invention is likely to be more utilizable if actively sought by the pupil and applied in some undertaking than if imparted when no such immediate need is apparent to the child. This calls for pupil

enterprises which create a mind set and a relevant occasion for mastering useful knowledge.

It is difficult to analyze the methods by which broad concepts are acquired, but they seem to grow gradually out of a long series of experiences illuminated by the consideration of much challenging and significant information. The first step is for the teacher to think through the broad concepts of science and to analyze them for the significant meanings that they embrace. Suitable experiences must then be devised for realizing these more immediate objectives and, through them, glimpsing broader relationships. Numerous meaningful experiences are necessary if these concepts are to function in the child's life. But broad concepts cannot be eventually comprehended unless the activities undertaken with this aim in mind are made to yield their significant meanings. Activity for activity's sake is ineffective. The children may make a collection of stones, but without the guidance of a teacher the project may not lead to a glimpse of the great natural forces at work on the earth. It is an altogether too common fault that our experiences end in the doing instead of leading to larger ideas.

Viewed both in the light of the philosophy of education through interaction and in terms of the definite aims of science teaching, undertakings that bring the child into direct educating relationships with his environment play a dominant role in method. It is apparent that, coupled with knowledge, such activities are capable of great educational possibilities. If a child could engage in this educating endeavor—visioning, planning, and achieving satisfaction from preschool age to maturity—what a rich childhood would be his. What power he might have as an adult to delve into the pressing problems of the betterment of human existence! Here surely is opportunity for teaching service on a professional level.

Role of Various Methods in Pupil Enterprises

The teacher who has followed this discussion of the importance of organizing the elementary science work in the form of pupil enterprises may feel that other methods of procedure are not given their rightful place. However, this is not the intent. The great value inherent in the pupil enterprise is the eager desire and purpose that it lends to all of his educational efforts. It largely renders unnecessary the less desirable forms of motiva-

tion, the stress on earning marks, and the continual dragging, driving, and repressing which still characterize much of our teaching. Children and adults will put forth efforts to complete an enterprise in which they are interested, which if imposed upon them in some other form would prove but drudgery. But the accomplishment of undertakings requires various procedures and offers abundant opportunity for employing many teaching methods and skills. There is a place for demonstrating procedures at times; for imparting information; for reading practice on new material which provides needed information; for expression through art, language, and construction; and for drill on processes and knowledge to be employed. The undertaking provides the general direction and motivation and seems to be the most ideal instrument of education, but it does not exclude the opportunity to employ the methods and techniques that we have learned. Rather it relegates them to their proper places in the educational process and increases their effectiveness as agencies for bringing about development through interaction. Since the work in elementary science ought to be largely centered about pupil enterprises, it is well that we further consider the general procedures for carrying out these undertakings, leaving certain specific methods and techniques to treatises on these subjects.

Criteria for Judging the Suitability of Enterprises

The enterprises should appeal to the child. From among the many that appeal to him, those undertakings should be given preference which seem to offer the greatest opportunity for rich and many-sided interaction. The enterprise must justify itself on the basis of its definite contribution to the aims of science teaching. The objectives must be realizable by the child. A common error is to select activities too difficult to accomplish. The teacher needs to try out a number of the activities that she has devised or obtained from project lists before she encourages children to undertake them. Children will express a desire to undertake many things that are practically impossible of achievement, although many of the interests thus evidenced can be directed into suitable enterprises. For children the undertaking should be relatively simple, tangible, and limited. The statement of the project should be in the language of the child and should show the limitations of the undertaking. One often sees project statements such as "to study trees," "to study birds,"

"to observe the stars," "to have experience with weather." Such undertakings are indefinite and could never be completed. To put up a feeding shelf and discover which of several foods some winter bird visitors like best is, on the other hand, a feasible undertaking. It suggests something definite to do. Moreover, it can be achieved in a reasonable length of time. When satisfaction has been attained, a new project can be started. The study of birds is not a project. Rather, it affords opportunity for a great many projects suitable for any degree of ability and educational maturity from the kindergarten through the graduate school.

Individual versus Group Enterprises

There are values in both individual and group enterprises. Individual undertakings probably develop more initiative and may result in greater satisfaction to the pupil. On the other hand, group enterprises teach cooperation. Moreover, a group can carry out projects of more extensive nature. It requires less of the teacher's time to direct group activities. Some enterprises should be undertaken individually, as some children may not enter actively enough in group undertakings to provide the interaction necessary to develop initiative. The same enterprise may be carried out individually by all, or by a large part, of the class. Where each child is to undertake a different enterprise, it is much easier for the teacher to direct such a program if all of the undertakings are of the same general nature or deal with phases of the same thing. It is almost impossible for any but the most skilled directors of activity to keep thirty or forty children profitably employed on wholly different types of projects.

Arousing Desire to Undertake the Enterprise

If we desire to develop initiative in the child, it is important that our method be such that he will regard each undertaking as his own, rather than as a task assigned by the teacher and executed under her direction for her approval. If he is to enter zestfully into the undertaking and attain the satisfaction through accomplishing it that seems to be such a significant factor in his education, his interest must be aroused until he is eager to undertake it. Unwilling to use other than the highest type of motivation—interest in the thing or idea—the teacher must be ingenious in arousing, detecting, and crystallizing children's interests. She

must be familiar with numerous activities through which these interests may find expression.

It probably does not matter greatly whether the enterprise is first suggested by the pupil or by the teacher, although some undertakings will certainly be initiated by the pupils. The teacher may simply say, "Shall we have a winter flower garden?" Even such a simple introduction as this will frequently call forth expressions from the pupils sufficient to convince the teacher of their mind set and readiness for the undertaking. If they are really interested in undertaking the project, they usually begin eagerly to suggest materials that might be used and ways of going about the task. This is usually the best criterion by which to judge their interest in the activity. For some undertakings which are not so easily visualized by the pupils, more careful planning is necessary to arouse sufficient desire to warrant the undertaking. For example, let us suppose that the teacher wishes to interest the children in a project in interpreting sounds. She may discuss with them how blind people manage to get along and know what is going on about them. One child may close his eyes and try to guess what other children are doing by the sounds that they make. She may raise the window and let the children try to discover what is going on out of doors by the sounds. Thus gradually the interest may be raised to such a pitch that they suggest or welcome the suggestion to go out of doors and learn to interpret from the sounds what is going on about them. There is no set method of arousing interest and desire for accomplishment. Objects brought into the room by the pupils or the teacher often develop interests which lead naturally to further activities. Any capable teacher with a little practice can learn to enlist the child's desire and his purposeful effort in achieving the desired result, instead of assuming the role of authority, imposing an assigned task, and assuring its accomplishment through his desire to win commendation and escape disapproval. Unless the pupils manifest eagerness to undertake the activity after an attempt has been made to arouse their interest, it is better to drop it for the present and suggest others that meet with enthusiastic responses.

Planning the Enterprise

The next important principle is that the children shall have as large part as possible in planning the procedure to be followed in

carrying out the enterprises. Too often the teacher lacking in professional understanding directs the children specifically how to proceed. Not only are the children thus robbed of practice in planning creative acts, but much of the joy and value of achieving is lost. The teacher's capacity here is an advisory one. She is a consultant who gives advice and suggestions where sought or where the child could not proceed alone, but she must not make it her undertaking. She must know when to give aid and when to let the child find his own way. Perhaps the commonest excuse given by teachers for planning the child's activities is economy of time. However, a little reflection on the aims of elementary education should convince any teacher of the unsoundness of such an argument. Our problem is not so much to store the child's brain with as many facts as possible as it is to provide avenues for the exercise of his powers that they may develop through functioning and expression.

It is important to know the child's plan of procedure in order to offer stimulating suggestions and questions where necessary. This can usually be accomplished in the following manner. After any individual or group projects have been selected, it is well to have each child make a statement to the class of his proposed procedure, including the materials that he hopes to use and where he expects to be able to secure them. The other children then offer suggestions, and the teacher has the final opportunity sympathetically to question or offer further aid. In this way the teacher is able to check all initial plans and to effect necessary changes. This procedure also possesses the advantage that all of the children become interested in each project. As the work proceeds, further planning will be necessary, but much of this can also be accomplished through the children's later reports to the class on the progress that they have made and the difficulties that they are encountering.

Carrying Out the Enterprise

Having purposed and planned, the child is ready to carry out his project. Those of us who have lived long enough to be teachers have learned that when we attempt to put our plans into execution, problems inevitably arise. It is akin to the difference between theory and practice which we so often hear emphasized. These difficulties which a child must surmount make the planning and executing of a purposeful act many times

more difficult than more passive forms of education. It seems equally evident that the process has much more educative value. Gain in initiative and power to do should be much greater in such a struggle environment. Having met and overcome difficulties, there is greater satisfaction in finally achieving the desired end, resulting in increased self-assurance and courage to meet new perplexing situations. The doing of the project is quite a different matter from observing the execution and describing or even explaining it. If the teacher carries it on entirely as a demonstration, it is she who meets most of the difficulties and surmounts them. Accordingly, it is she who is exposed to the greatest educational process for the development of initiative, not the pupil.

It should be clear to the teacher that she is not to direct the child specifically how to proceed, as did the laboratory manuals handed down by the colleges to the public schools. She has aroused the child's desire to accomplish an undertaking that is within the limits of his ability, and she has satisfied herself that he has a hopeful plan of procedure which warrants his efforts. She can now afford to make herself inconspicuous, giving only such aid as is needed. One of the mistaken ideas apparently held by many teachers is that they must always stand before the class and hold a formal recitation in each subject daily. Much of the demonstration teaching in the training of teachers possibly heightens this misconception, as the phases demonstrated are usually the launching of an undertaking or the bringing together of information at the close of the activity, in which the teacher's role is a more prominent one than in the busy intervening work days. Although less conspicuous, the teacher's role is no less important during the work periods, for most of her time is given over to acting as consultant. In addition, there are always a few children with less initiative who require a greater amount of encouragement and assistance, and a few superior ones who can be stimulated to further achievements. Sometimes it is advisable to call the children together for brief reports on the progress that they have made and the difficulties that they are meeting or to give needed assistance to the group as a whole. This plan can always be resorted to whenever the teacher finds her time insufficient to get around to help each child individually.

Some of the work will be done out of doors, and a few words of advice on conducting field work may be helpful. It is unfortu-

nate, but true, that many teachers hesitate to undertake work outside the schoolroom on account of the disciplinary problems involved. The schoolroom atmosphere ordinarily has exerted something of a repressing influence, as does that of a church. Children emerging from this atmosphere to set forth on a field trip without definite purposes which they hope to attain within the short time available frequently disport themselves in a manner akin to that of young energetic horses when the stable door is opened. Such situations are wholly unnecessary, and the teacher can be just as much at ease conducting work in the field as within her classroom. If the work indoors were conducted in a manner as aimless from the standpoint of the pupil as is much of the field work, undirected energy would soon flow into disturbing channels in the schoolroom. It is not sufficient that the teacher have a purpose for the period spent in the field. The pupils should have definite desires and plans before they leave the schoolroom. The teacher will find it advisable to make the first field period rather short—hardly sufficient to accomplish the purpose at hand—and to select activities that can be accomplished near the school. The children should know just what materials or data they plan to secure and should immediately proceed to obtain them. In this way the teacher, instead of leading her group of blind followers, accompanies them to consult and render assistance, as she does when the group is working in the classroom. By proceeding in this manner, children soon acquire an attitude toward field work that makes it possible to have them working on individual enterprises in the open. Within the limits of safety the teacher will soon find it possible to allow some children to leave the schoolroom whenever their work demands it, while others continue their activities within the room. Many projects can best be carried out at home, at least in part. There is ordinarily no objection to this type of homework. Where much of the work is being done outside school hours, the science period is nevertheless needed to coordinate the work.

It is highly important that the project be pushed to a satisfactory conclusion. This should be done even though it requires encouragement and minor aid on the part of the teacher when the child's purpose weakens before the outcome is achieved. Wherever it is possible to do so, it is advisable to have the results in some tangible form which can be preserved and will continue to afford the child satisfaction in his achievement. Some of these

project outcomes make attractive schoolroom decorations. Children who thus contribute to the equipping of their schoolroom come to feel a great interest in it which is reflected in their general attitude. The products of creative undertakings also make useful displays to interest parents in the work of the children and to educate them in the activity program of the school.

Utilizing the Enterprises As Points of Departure for Further Learning

The activities create occasions and mind sets for many associated learning experiences. During and after the execution of the projects, children should be encouraged to write and to read simple material in the general fields of interest opened by the undertakings. Additional trips may be made to gain further direct information. There may be talks by workers in the fields covered by the enterprises, appropriate moving pictures, poems, plays, and a great variety of supplementary experiences. The teacher should constantly try to discover the effect of the project work and associated activities on the children, considering evidences of the development of desirable traits as well as knowledge outcomes. Adding fixity to the present state of the creative program in science through overemphasis on standardized subject-matter tests would be very unfortunate, although objectivity in measuring the results of our efforts is altogether desirable.

There is another unfortunate tendency which may properly be considered here, as it greatly restricts the child's possible points of departure for further learning. Some teachers follow the practice of dividing the class into groups and allowing each group to carry on enterprises in only one field such as studying birds or growing plants. Other teachers extend an activity over a large part of the school year, thus greatly limiting the range of the child's experience. It is much better to interest children in carrying on a wide range of activities in each grade. No subject is to be studied exhaustively in any grade. Moreover, it is not wise to carry on after the intense interest wanes and children begin to say, "Let's do something else." It is then time to arouse new interests and desires, shift the scenes, and begin the process of creative education anew.

CHAPTER V

SCIENCE IN OUR CHANGING ELEMENTARY CURRICULUM

Fundamental Changes in Progress

Most educators have been impressed with the inertia of the conventional school. The unprecedented momentum of the present movement to revise the curriculum is, therefore, almost startling. The ideas employed are not new, as all students of the history of education are ready to attest, but the emphasis and the tendency to action are more marked. Bruner[1] stated in 1931 that "America has witnessed in the last decade more activity in curriculum and course of study construction than in all its previous history." In support of the statement he presented the following among other data. "Prior to 1920 fewer than 1500 courses had been published in the United States. Since 1925 more than 30,000 courses have been collected in one laboratory alone." Concerning their nature, to quote Bruner further:

> While many of these courses of study are poor in organization and content, literally hundreds of them are beginning to contain a scope and depth of materials and methods little dreamed of in courses ten years ago. They are surpassing in many points the best of our textbooks and supplementary materials. In fact some of the outstanding courses seem to be harbingers of what textbooks will, in all probability contain.
>
> What a contrast this outstanding type of course of study makes with the old type. The old type course contains little more than bare references to existing textbooks. Its chief aim is to dictate just what pages in the textbook should be covered during any given period of time. The methods of teaching and learning compelled by such a course are formal and inflexible. In the classroom the "teacher versus the pupil" attitude is assumed; the question-and-answer method is adopted; the "stand up" and "sit down" procedure predominates. A very limited amount of materials, many of which are often of little use to the child or adult now or later, is employed. In the elementary school the day is divided into small periods of ten, fifteen, and twenty minutes during

[1] Quoted by permission from "Curriculum Making in Current Practice," a report of a conference held at Northwestern University, Oct. 30–31, 1931. Evanston, Illinois: School of Education, Northwestern University, 1932.

which teachers attempt to have the child learn small bits of unrelated information or certain discreet skills. Children under the old scheme, are given little opportunity to form judgments or to follow through with their own interests.

These statements were written in 1931. There is much evidence that the movement is continuing, as some of the best courses of study in elementary science have since appeared. It is more than a temporary diversion. Once the task of constructing a curriculum to meet the needs is seriously undertaken, there is no stopping point. It is the dedication of education to the problems of a changing society.

Some Reasons for Curriculum Changes

Everywhere there is a growing consciousness of needs that are not being satisfactorily met. The needs, in turn, have their origin in significant changes which are taking place. There are changes, both within and without the field of education, that call for the redirection of our efforts. Shift of emphasis in psychology and educational philosophy is proving a decided stimulus to reorientation of education. From emphasis on specific responses to specific stimuli, attention is turning to the study of growth and development. Interest is in the child, his development through interaction, and his attainment of self-direction. This implies an active rather than a relatively passive education, emphasis on the child as a developing organism with a personality instead of "an empty head to be stuffed," on pupil purposing and achieving rather than forced learning. In the light of the more dynamic psychology and philosophy, traditional school training, with its curriculums of none too critically selected facts to be learned as assigned by teacher authority and tested as factual rather than functional outcomes, is very inadequate.

Sociological forces are also a major factor in redirecting education. As is true of the developmental viewpoint in psychology, social values are not new in education. Eventually they might have emerged as a dominant consideration in curriculum construction as a result of developments in the field of educational sociology. But they have been boosted to front rank among educational considerations by the social and economic situation. The necessity for social action, the inertia and antagonism to change, and the dependence of democracy upon a socially conscious and enlightened citizenry have convinced

educators generally that educational effort must be directed toward social ends.

Another reason for reconstructing our courses of study is aggregation. We sometimes accumulate in our desks and our files so much material and so many diverse items that our operations are being restricted. It is necessary to reorganize our belongings. Some of the items can be thrown away as no longer needed. We find that certain others, acquired at various times and under various circumstances, will be more likely to prove useful if filed in the same folder. Elementary education has found itself in this condition. In response to demands, subjects have been added to the curriculum from time to time, and there has been little reorganization, combination, and elimination. The result has been to reduce the time for each class period to a few minutes and to preclude the possibility of redirecting instruction along psychologically and sociologically indicated lines without reorganization.

The Teacher and the Curriculum

In the past the teacher had little or no part in determining the curriculum. The course of study was placed in her hands to be carried out. Her duty was to adhere to it as closely as possible. In many school systems her strict adherence to the printed course was checked through the lesson plans which she was required to prepare and submit to her administrative or supervisory officer well in advance of her teaching. Deviations from the prescribed course of study, either in order of arrangement or in substance, met with disapproval. The examinations called for rather close reproductions of the specific learnings.

Today the teacher's relations to the curriculum are changing. Wherever understanding prevails, the course of study is regarded as a general guide to some of the desired outcomes. If it is rich in suggestions, these are welcomed by the teacher. The course of study is not the daily taskmaster. The teacher is much freer to plan the work according to her understanding of the needs of the children.

In numerous cities and villages throughout the country, teachers are at work constructing and revising curriculums. Many state courses of study are prepared by committees of teachers. The tendency is distinctly toward teacher participation in curriculum construction. Practically the only argument

against allowing teachers to plan the curriculum has been their inadequacy for the task. They have commonly been thought to possess neither the broad professional comprehension nor the understanding of the subject matter necessary for curriculum construction. There is little doubt that this has been rather generally true in the past. A very large proportion of elementary teachers have been poorly prepared both professionally and academically. This has been the justification for the highly prescriptive nature and the slavish use of the courses of study. With the coming of the teacher who, because of her cultural background and her professional understanding, is able to assume a more responsible role in education, the relationship of the teacher to the curriculum is changing.

The most advanced stage of this changed relationship is to be found in certain activity and progressive schools. In some cases the curriculum is not formulated in advance but is built by the teacher and the class as the work proceeds. One experience leads to another. Organization of the curriculum in advance is held to be undesirable in that it interferes with freedom to follow the natural course of development. The proponents of this procedure point out that the organization of learning is achieved by the child only as each succeeding experience is viewed in somewhat wider relationships with his existing mental world.

There is hope for the future in the changed relationship of the teacher to curriculum construction and to supervision. What a far cry from the subservient and routine teacher of the conventional school to the responsible director of activity in the new school. Whether or not we consider the procedures of the most modern schools advisable, we must give the professional teacher new and greater responsibility in planning the curriculum. It is she who comes in direct contact with the children. If she is adequately trained and experienced in directing learning, she has a very valuable contribution to make in curriculum construction.

The Eclectic Approach to Better Curriculum Construction

In discussing the reasons for curriculum changes, two great influences in shaping education—the psychological and the sociological—were considered. The psychological view places emphasis on fostering the development of the individual. The sociological view places the emphasis on adapting and often

subordinating individual tendencies to group needs. So long as bond psychology held sway, with its emphasis on specific learnings, the conflict between the two approaches was not so apparent. The specific learnings in conformity with social needs could be woven into the curriculum. Thus the curriculum formulated in accord with the psychology of specific learnings and the sociological viewpoint of education as adjustment to existing social needs was of a tangible nature. The course of study could be a very definite document indicating exactly what must be learned, although actually no course of study to prepare for the existing order so fully prescriptive ever appeared, as the schools never kept abreast of educational philosophy.

Such courses of study, however, do not fit either the present developmental viewpoint of organismal psychology or the enlarged sociological aim of participation in a changing social order. The psychological and sociological viewpoints have given rise to two procedures in curriculum making, which have frequently been considered in opposition. One group would have the course of study rich in suggestive material for providing educating experiences for the growing, developing child. It would not have it consist of prescribed subject matter. The opposing group, impressed with the need for more effective action along certain lines, would have the course of study stress the desired outcomes together with carefully planned steps based on analysis of the goals and intended to direct training toward these ends.

An eclectic approach seems feasible and desirable. As John Dewey[1] points out:

> There is a great deal of elasticity within an individual; individuality is rather a *direction of movement* than anything definitely formed. Selection and arrangement have to occur anyway unless everything is carried on at haphazard according to the caprice or pressure of the moment. The problem is therefore to discover within present experience those values that are akin to those which the community prizes, and to cultivate those tendencies that lead in the direction that social demands will take. If emphasis is put upon these points of community, not all clashes of personal desire and social claim will be avoided, but in the main there will be growth toward harmony.

[1] Quoted by permission of the Society from the comment in the Thirty-third *Yearbook* of the National Society for the Study of Education, Part II, pp. 84–85, Bloomington, Illinois: Public School Publishing Company, 1934.

The very dependence of the young establishes within their own makeup response to social demands.

Another factor that has greatly tended to lessen the conflict is the enlarged sociological viewpoint which recognizes more than immediate existing needs. Existing needs are temporary, changing goals, and it is not always possible to foresee the direction of social change and consequent educational need. Under these conditions, elasticity and the ability to function in changing situations become of paramount importance. Democratic society is dependent upon the development of this ability. Here developmental psychology and the broader sociology meet in a common purpose. Viewed from this common ground the curriculum is to be regarded as a wealth of experience in attaining self-direction. The experiences should grow out of the many natural tendencies of children. Effort should be directed along the line of those natural tendencies that offer the greatest opportunity for attaining self-direction in present and probable future social problems.

What are the natural tendencies and interests of children which we are to utilize in planning experiences in self-direction along socially valuable lines? How do they differ at the various grade levels? Are there individual and sex differences? Some attempts have been made to study children's interests in science subjects and materials. Perhaps the most extended attempt to study children's science interests and to utilize them in curriculum making is in progress in the Cleveland schools, where they are[1] "endeavoring to construct a course of study based upon the fundamentals of the children's natural interests and the proper adjustment and proportional distribution of units that should be about animal life, plant life, and the physical sciences."[2] Palmer, Mau, Downing, and Finley, approaching the problem experimentally, each found children's interest to be greater in animal life than in physical nature and plant life. On the other hand,

[1] MELROSE, MARY, The Evolution of the Elementary Science Program in the Cleveland Public Schools, *Science Education*, 17: 4, February, 1933.

[2] The studies by Trafton, Finley, Mau, Downing, and Craig along this line are discussed briefly in the chapter "Contributions and Needed Studies in the Field of Elementary Science Education." Abstracts of the studies may be found in Francis D. Curtis, "A Digest of Investigations in the Teaching of Science," "Second Digest of Investigations in the Teaching of Science," Philadelphia: P. Blakiston's Son & Company, 1926, 1931.

at the Doan Center in Cleveland physical science interests have greatly exceeded those in animal and plant life in each of several rankings made in June, December, and March. Slavson and Speer[1] found that physical science materials held children's interests much longer than did biological materials. The results of the investigations are not strictly comparable, as a number of conditions differed. At present, one is forced to conclude that we do not have the answer to the problem.

There are some indications that these interests are not the inevitable result of inherent nature and development but are greatly influenced by experience. Miss Melrose, in the Cleveland study, found that following a unit on trees this phase jumped from seventh to second place among science interests of school children. Radio talks and the use of microscopes increased the interest in bacteria, yeasts, and molds to a marked degree. There are many familiar examples of activities in which we were reluctant to engage that have now become absorbing interests. The extent to which we are attracted to any phase of our environment is dependent, at least in part, on the amount and nature of the experiences that we have had with it. It is probable that we shall find that there is no one grade in which we should study animals or plants or physical objects and forces. It is likely that we shall discover suitable experiences in all phases of the environment to challenge the interests of pupils from preschool age to the postgraduate level. The potential interests of children are wide and varied. The problem from the standpoint of curriculum construction and schoolroom practice is to discover what approaches to these challenging phases of the environment are suitable at each level of experience and school training and then to enlist the interests of children in the most socially valuable of these activities.

Using a rather elaborate technique, Craig[2] has approached the problem of the elementary science curriculum from a different angle. An extensive survey of existing practices in the teaching of elementary school science revealed very little organization

[1] SLAVSON, S. R., and ROBERT K. SPEER, "Science in the New Education," New York: Prentice-Hall, Inc., 1934. 384 pp.

[2] CRAIG, GERALD S., "Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School," Contributions to Education No. 276, New York: Teachers College, Columbia University, 1927.

of the field. He then proceeded to set up certain criteria which were in the nature of general goals. By analyzing volumes of the *Nature Study Review*, courses of study, professional literature, and authoritative treatises on science, specific objectives in the form of declarative sentences were obtained which seemed to contribute to these general goals. These specific objectives, revised on the basis of the criticisms of twenty professors and instructors of science, were submitted to various groups to be evaluated and ranked as to importance. The statements of specific objectives were further evaluated on the basis of children's questions. The list was then checked against a set of significant statements obtained by studying forty-nine treatises on science, and certain sequences noted. Finally, a course of study was formulated using as a basis the revised list of specific objectives. Each objective was broken up into themes. Each theme was assigned to what seemed to be the appropriate grade level. Those verifiable by observation or basic to the understanding of others were placed in the lowest grades. The result was a course of study[1] designed primarily to lead to comprehension of the broader generalizations of science, although concomitant skills, attitudes, and appreciations were considered.

This contribution is proving a decided stimulus to progress in curriculum construction in high-school and college science as well as in the elementary school. The broad generalizations of science serving as goals possess great directional value. Redirection of instruction is in progress in many places, as a result of which otherwise more or less aimless and unrelated learnings are made to contribute to valuable educational outcomes. Tyler's[2] study of the permanence of various types of learning in college zoology gave striking results which tend to support the view that principles are retained and become increasingly functional, while specific information is largely lost. His tentative conclusion is interesting:

> If these results are substantiated by further investigations, it is clear that the permanent results of the college education are not the specific

[1] CRAIG, GERALD S., "The Tentative Course of Study in Elementary Science for Horace Mann School," 3 vols., Grades I and II, III and IV, V and VI, New York: Bureau of Publications, Teachers College, Columbia University, 1927.

[2] TYLER, RALPH W., "Some Findings from Studies in the Field of College Biology," *Science Education*, 18: 3, pp. 133–142 October, 1934.

items of information recalled, and that the organization of courses and the development of examinations should center around those objectives which are found to have more permanent value in college education.

We do not know whether this applies to retention of learnings generally at all ages.

It would seem that we can accept the point of view that the broad generalizations of science have much guidance value and that they are an important element in curriculum construction. This is not necessarily out of harmony with either the newer psychological or the newer sociological concepts of education. Developmental psychology would recognize mastery of the generalizations of science as a factor in attaining self-direction and integrated development. Sociology would recognize their social value. There are, however, other factors than these generalizations which must be considered in our eclectic approach from both a psychological and a sociological consideration of the curriculum.

The immediate determining influences in curriculum construction ought to be our aims growing out of the changed psychological and sociological outlooks. Comprehension of the generalizations of science is only one of the needs of the individual for self-direction in a changing society. It is too much to hope that leisure-time interests, scientific attitudes, ability to use scientific knowledge in specific situations, and social attitudes and appreciations will be developed in connection with understanding of these generalizations. We must take into consideration all of these aims in planning the curriculum.

Some educators are stressing the knowledge outcome as essential to intelligent functioning. They fear that a curriculum determined as described in the preceding paragraphs will not result in definite learnings which are regarded as essential. Owing to these conservative forces, it is likely that most courses of study planned in the near future will include statements of subject-matter outcomes. Two methods have been used to insure these specific learnings in the modern school. They may be stated and tested in connection with each experience, or remedial instruction may be undertaken during the latter part of the school term wherever comprehensive testing indicates the need.

What, then, would be the nature of the course of study for a curriculum arrived at by the eclectic approach? It would not be an outline of subject matter arranged by topics or units

obtained by subdividing the knowledge within a field. It would stress the desired outcomes in terms of social and personal matters in which the attainment of self-direction is desired. A very large number of suggested experiences intended to lead to self-direction in these matters would be included. There would be enough suggested experiences to allow selection in accord with the natural tendencies and interests of children. Each experience would be sufficiently described and analyzed in terms of method and outcomes to provide stimulating suggestions in usable form for the busy teacher. Neither the selection of experiences nor the procedure would be prescriptive but only suggestive. A minimum of definite learnings essential to self-direction in these matters would be definitely stated, not merely listed as topics. Any available assistance to the teacher in determining the progress of the pupils would be included. Measurement would be primarily diagnostic. New forms of measurement for the broader aims of teaching would be included whenever they become available.

The Problem of Integration

The tendency in planning curriculums is distinctly toward integration, especially in the earlier school years. This is a natural consequence of the shift in emphasis from the subject matter to the developing child. The experiences of childhood are not to be sectioned according to arbitrary fields designed for more intensive acquaintance with single aspects of knowledge. Partition of the day into brief periods devoted to specific learnings in the separate subjects is not in accord with the growing concept of education. It probably tends to disorganize the growing child's personality rather than to integrate it. It furthermore tends to place emphasis on unrelated learnings rather than attainment of self-direction in natural units of experience.

The integrated and unified curriculum is not to be confused with the correlation of subjects, which recognizes relationships of learnings rather than integration through experiences. The ideal elements of the integrated curriculum are suitable experiences for child development. The usual designation of subjects is entirely disregarded. Reading, music, art, science, mathematics, and the social studies do not play separate roles in the integrated program, nor are they dragged in to correlate with each other. The undertakings selected should be the richest

experiences in living that the school can provide, and any experience may involve several or all of what we have in the past considered to be the school subjects.

What, then, is to be the unifying element in the elementary curriculum? There are many indications that the child's greatest interest is in himself and his contacts. Records of children's conversation reveal that they talk mostly about themselves and their own affairs. We do not welcome such tendencies in adults, and we certainly do not wish to educate individuals to be entirely self-centered. But we cannot afford to overlook the opportunity in education that this tendency in childhood presents. We may educate or lead the child out into wider interests through utilizing his present self-centered acts.

The child's eager interest in social contacts and our growing recognition of need for social action have led many curriculum makers to center the work of the elementary school about the social studies as a core. There is no doubt that social contacts are a major interest at all age levels. Viewed broadly, perhaps they affect most of our activities throughout life. But relations with human beings are only part of the child's education. His contacts are with other forms of life, with inanimate objects and forces as well as with people. It is probably true that his interests are not intrinsic in these things but only in his attainment of satisfaction in his contacts with them. However, to assume that his interests are only in human contacts is to fail to recognize a large part of his educational interactions. The curriculum is not to be centered merely in the child's social contacts but in the experiences of childhood, with the individual child always the central figure.

What part is science to play in the integrated curriculum? The answer is, as science, nothing; as a contributor to the unified program, a very large and important part. It is one of the important elements in attaining satisfaction and self-direction in our contacts with objects and forces. It also plays a part in certain social contacts. Most of the undertakings in an integrated curriculum include experiences that would be included in elementary science in nonintegrated school training.

Making the Best Use of Existing Courses of Study

Many teachers find themselves in a situation where they must use a course of study that is not in accord with best current

educational thought. The syllabus may be little more than a list of science topics arranged by months. In this case the problem is not so difficult, as the teacher is at least free to organize and direct the work assigned for the month as seems best. The highly prescriptive course of study which lists a large amount of specific information, rather unrelated and poorly selected, presents a much more difficult problem. The situation is further complicated if the principal or other supervisory officer is as stereotyped as the course of study. In most cases, however, it is possible to effect a reorganization of the material to accomplish the desired outcomes. A good teacher can achieve some of the objectives of science teaching with almost any of the existing courses of study, if she clearly visions the needs and proceeds with reasonable tact and skill.

The first step is to formulate very definitely the aims to be accomplished without regard to the existing syllabus. These may be listed under major aims, as stated in Chap. III, or in some other desired form. They must be definite enough to serve as goals in the redirection of the work outlined in the course of study. The vague statements of aims found at the beginning of such documents are insufficient for this purpose. It is not enough to realize that the teacher desires to open new avenues of interest and satisfaction or to contribute to social attitudes and behavior. It is necessary to list the avenues for finding satisfaction and the social outcomes which are to be the prized goals of her efforts. In like manner, she will decide upon the more specific outcomes under each major aim.

With a clear understanding of what she desires to accomplish comes a realization of the worth-whileness of her efforts and a determination to make the science work contribute to the child's life. She is now ready to consider ways and means. If she is not already a skillful director of children's activities, it will prove helpful to read the chapter on "The Importance of Method" and to consult more complete treatises in this field. Above all, let her visit a skillful teacher with a professional outlook to grasp the spirit of vitalized and purposeful school work.

Now when she takes up the course of study, the topics and factual learnings have enriched meanings and usefulness. They are seen not as unrelated facts to be recited and tested but as means to achieve important functional outcomes that she has selected. It is too much to expect that the course of study

will resolve itself suddenly into suitable challenging experiences for accomplishing vital aims, but this is truly the transformation that is beginning to take place. What the teacher needs now is suggestions—many of them. Being a busy person who has only a limited amount of time for planning undertakings, she needs rather full suggestions and examples of successful experiences which other teachers have directed. New courses of study rich in suggestions for experiencing are beginning to appear.[1] The teacher who has some of these stimulating courses on her desk will find them a great help in revitalizing the older type of course which she is expected to follow. They will suggest meaningful experiences with the otherwise uninspiring units of the traditional course of study. Perhaps this is another way of saying that courses of study and curriculums can be made functional by a vital professional teacher. She is the essential and the most important ingredient.

[1] One of the best of these is the Maryland School *Bulletin* "Science in the Elementary School," published by the State Department of Education, Baltimore, Maryland.

CHAPTER VI

APPRAISING THE RESULTS OF OUR EFFORTS

Appraisal Inherent in Teaching

We are constantly appraising the results of our efforts. The criteria are not always the same. The methods of appraisal differ. Various uses may be made of judgments once they are arrived at, but we all judge. Whenever we attempt to decide the needs or the progress of any pupil, the success or failure of any procedure, we are either estimating or measuring. Our judgments often involve a combination of measurement and estimation.

As teachers, we plan and launch our procedures, appraise the results, shift our attack, and continue to regulate our efforts in the light of the changes produced in the pupils. All of these steps may occur within one school session. Appraisal is not something tacked on to teaching. It is inherent in any teaching that does not proceed blindly.

Uses and Limitations of Measurement

If a valid and reliable instrument is available for measuring any process, its use is to be encouraged wherever accuracy is important. If various workers using the instrument to measure the same quantity arrive at results that are in close agreement, this objectivity further enhances its value. Valid, reliable, and objective measuring instruments are as much to be desired in education as in medical practice, industry, or any other form of endeavor. This is just as true of the more vital education for enriched existence as when memorization was stressed. It is just as desirable to know the extent of the child's progress in self-direction and social action as in factual learning, but the task is not so simple.

To assume that functional or behavior outcomes are not measurable is not only unscientific but would definitely stifle

advancement. However, it is important that teachers understand the present limitations of measurement. In the first place, the development of suitable methods of measuring functional outcomes is greatly retarded by lack of clearly defined aims. Measurement is a refining process. Until we know what we are striving to achieve, we cannot hope that methods of measuring progress along this line will be developed. This applies very definitely to the elementary science situation. We are in the process of clarifying our aims and in the beginning stages of measuring progress toward their realization.

In the second place, we must recognize the fact that we never measure anything in its entirety. The physician samples temperature, pulse, blood count, hydrogen-ion concentration, etc. If he could completely measure these facts and many more, he would then have only certain indications as to the state of the patient. They are invaluable in diagnosis and treatment, but thoughtful physicians recognize that they are only a partial basis for appraisal. Educational measurement possesses similar values and limitations. Full realization of these limitations would clarify much of the conflict being waged today for and against measurement.

In the third place, attempts at comprehensive measurement are not always warranted in practice. Anything approaching a complete physical examination is seldom attempted by the medical profession, except in especially baffling cases, on account of the great amount of effort, time, and expense entailed. The progress of the patient is often so evident as to render elaborate measurement unnecessary. If our plants are growing thriftily and producing abundantly, it is better evidence that our soil and cultural methods are good than could be obtained by fragmentary measures of the various factors. Likewise, in education there are many evidences by which we may judge our achievements. Measurement is not always demanded. In some situations the results would not justify the time and effort required.

We must also realize that some outcomes are difficult to measure with precision. Attitudes, appreciations, the ability to express and the tendency to apply knowledge, and even understanding must be so regarded. This limitation is recognized rather generally by workers in the field of measurement. It was one of the chief limitations encountered by the commission on the social studies in their work on "Tests and Meas-

ures in the Social Sciences," as evidenced in Part IV of their report.[1] There is a tendency on the part of some teachers to condemn all attempts at measurement that have not reached a highly objective stage. We even hear the statement that it is better to leave such matters entirely to subjective judgment. However, any method of estimation or appraisal that increases the likelihood of arriving at accurate judgments is to be welcomed. There is also the duty to encourage the attempts to perfect these measures in the hope of improving our professional services.

The Misuse of Measurement

Having considered the uses and limitations of measurement, it is in place to offer a few words of caution against the misuse of tests. The reaction against the measurement movement in education is due more, perhaps, to misuse than to its limitations. Like fire, measurement is a good servant but a bad master. When the teacher's efficiency is judged primarily by tests of factual learnings applied to her pupils, and when the important problem of stimulating development in self-direction is lost sight of in the preparation for tests, then measurement becomes a bad master. There is little doubt that it has tended to machine the process of education in many schools and to place the emphasis on subject-matter drills rather than on child development. This is particularly true of the survey use of measurement with its overemphasis on standardization of very inadequate educational outcomes. One of the purposes of the course in measurement suggested in the chapter on the preparation of elementary science teachers is to prevent just such misuse of testing by persons untrained in this field. So long as the teacher understands the limitations of measurement in appraisal, there can be little objection to its diagnostic use. In the hands of a trained teacher it is one of the valuable instruments of appraisal and guidance.[2] Nor is it limited to appraisal of factual learnings. With the change in aims, a corresponding redirection of measurement is developing.

[1] KELLY, TRUMAN L., and A. C. KREY, Report of the Commission on the Social Studies, Part IV. New York: Charles Scribner's Sons, 1934.

[2] The discussion here is limited to achievement tests, as the interest in intelligence tests is common to all fields.

Tests in Elementary Science

Relatively few tests in elementary science are available. This is probably due to the fact that science has only recently come to be more than an incidental phase of elementary training. When some degree of agreement is reached in regard to aims and procedures, we may expect the appearance of many more measuring instruments. It is quite unlikely that the teacher concerned with the outcomes discussed in the chapter "Aims in Science Teaching," and in other recent discussions of the subject, will find that the tests now available reveal what she wishes to know about the progress of her pupils. In some cases, they may help her to judge the informational background for achievement. In most situations she will have to rely upon tests of her own making and other methods of appraisal which will be discussed under the last topic in this chapter.

Some of the tests now on the market are here listed without attempt to evaluate them. Many others are in use but have not been made available by publication. It seems unnecessary to classify the tests now offered for sale, as the number is so small that any teacher may easily become acquainted with all of them.

Analytical Scales of Attainment, A. Dvorak and M. J. Van Wagenen. Range: division 2, grades 5–6. Forms A, B, C, Minneapolis: Educational Test Bureau, 1933. (Includes elementary science.)

Stanford Achievement Test, T. L. Kelly, G. M. Ruch, and L. M. Terman. Range: grades 4–8. Forms A and B. Yonkers-on-Hudson, New York: World Book Company, 1922. (Includes nature study and science.)

New Stanford Achievement Test, T. L. Kelly, G. M. Ruch, and L. M. Terman. Range: grades 4–9. Forms V, W, X, Y, and Z. Yonkers-on-Hudson, New York: World Book Company, 1929. (Includes physiology and hygiene.)

Omnibus Achievement Test, C. W. Odell. Range: grades 6–8. Urbana: Bureau of Educational Research, University of Illinois, 1922.

Public School Achievement Tests, Forms I and II by J. S. Orleans; Forms III and IV by T. L. Torgerson and Glenn A. Sealy. Range: grades 4–8. Bloomington, Illinois: Public School Publishing Company, 1931. (Includes nature study and health.)

The Modern School Achievement Tests, A. I. Gates, P. R. Mort, P. M. Symonds, R. B. Spence, G. S. Craig, De F. Stull, R. Hatch, A. I. Shaw, and L. B. Krieger. Range: grades 2–9. Forms I and II. New York: Bureau of Publications, Teachers College, Columbia University, 1931. (Includes elementary science.)

Unit Scales of Attainment, M. E. Brannon, L. J. Brueckner, A. M. Jordan, P. Cutright, W. A. Anderson, M. G. Kelty, A. Dvorak, and M. J.

Van Wagenen. Range: forms A, B, and C. Division 1, grades 3–4; division 2, grades 5–6. Minneapolis: Educational Test Bureau, 1932. (Includes elementary science.)

Need of New Measuring Instruments

We have already realized that existing tests are inadequate to measure progress toward many of the desired outcomes of science teaching. Let us now consider the types of measuring instruments that are needed. On the basis of a questionnaire dealing with evaluation of outcomes, which was submitted to a number of schools known to be working with an activity program, Mildred English states,[1] "Adequate measures are reported lacking for the purpose of measuring growth in habits, attitudes, and appreciations; in ability to use knowledge and skills gained; in ability to place, to judge, to choose worth-while activities; to assume responsibility; and in the creative arts." One of the best statements of the need of new measuring instruments is that by Alice V. Keliher, who points out that "we must somehow test the bases of growth and development!" Every teacher ought to read her challenging discussion[2] on the orientation of measurement in the activity program in Part II of the Thirty-third *Yearbook* of the National Society for the Study of Education. A few of her suggestions are quoted here because they express so clearly some of the outcomes for which methods of appraisal are urgently needed.

Other techniques must evolve to answer vital questions. How is this scientifically acknowledged urge of self-activity expressing itself? Does a child participate? In what? How often? With increase of judgment? In how many fields of activity? Socially, intellectually? Is the child's curiosity expressing itself? Does he feel free to ask questions? Does he attempt to answer them in so far as possible himself? Does his curiosity take him into exploits that add to his store of inner wealth? Are his questions taking in wider realms of import? Does he sensitively explore his environment? Is he learning from year to year which forms of exploitation are socially acceptable and which are not? Is he learning year by year to manipulate ideas, materials, and tools of civilization? Is he seeking after increasingly abundant realizations in his own life?

[1] Quoted by permission of the Society from "The Activity Movement," Thirty-third *Yearbook* of the National Society for the Study of Education, Part II, p. 150, Bloomington, Illinois: Public School Publishing Company, 1934.

[2] *Op. cit.*, pp. 159, 161.

Is he learning year by year how to take over the responsibility for his actions and *is* he taking it? Is he learning the joy of self-expression through creating? Is his creating, year by year, reaching into new levels? Is he being exposed to the experiences, to the people, to the situations through which his appreciations may be widened and deepened? These are all questions we must ask ourselves about the children whose lives are committed to school education. . . . Neither can we satisfy ourselves with the argument that these values we seek are unmeasurable. There are ways of finding out the directions growing learners are taking and we who find the present standardized test inadequate must set ourselves to the task of finding other means of gauging growth.

What challenging questions to ask ourselves concerning our pupils! How we shall value any improved means of appraising our efforts to achieve these dynamic outcomes! We need measures of the child's functioning as an organism that will give us a better picture of his reactions in the complex situation in which he finds himself. Especially do we need long-time measures of his growth in self-direction in these situations.

Eclectic Appraisal in Elementary Science

The teacher who is vitally concerned about the functional outcomes of her work will be eager to know to what extent her efforts are changing the lives of the pupils. She will be alert to all evidences of development, whether they appear incidentally or as the results of her planned efforts at evaluation. It would be a limited type of education that could be appraised by a single method. The more varied are our aims the more we need to employ a number of means of evaluating achievements. Always it must be our aims that determine our efforts, whether in directing experiences or in judging their outcomes.

One of the most important aims in elementary science is to open new avenues of interest and satisfaction. The best indication as to our success in such efforts is the tendency of our pupils to spend a part of their leisure time following the avenues that we have attempted to open. Children like to tell and to exhibit what they have done and will reveal much in this way if an opportunity is provided. Reports by parents are very helpful. Some indication may be gained from the child's selections of books to read. Oral- and written-essay types of examinations

may help. Little has been done in the way of new type tests for this purpose.

The development of broad concepts and wider outlooks is difficult to measure. Background information and understanding of principles essential to the concepts can be tested in part by means of new type tests. The functioning of this knowledge in one's perspective does not necessarily result from its acquisition. It ought to be possible to devise tests of the concepts that children hold which would be valuable in appraising development along this line. At present, the teacher will have to depend largely on evidence revealed through the points of view expressed by children in the course of informal discussion and writing. By skillfully directing the discussion, one person can usually discover the concept that another holds. This is especially true in dealing with children who ordinarily have not learned the art of concealing their views.

Assuming that we have decided what knowledge and skills our pupils need to apply in meeting their problems of existence, we gain some idea of where we need to begin through the use of suitable pretests. New type tests and certain standardized tests reveal something of the child's knowledge of these essential matters. Performance tests are needed for the essential skills. We can test the pupil's progress in acquiring both the essential skills and the utilitarian knowledge necessary for the accomplishment of this aim. However, possession of knowledge and skill does not insure their functioning in his daily life. A child may know that he ought to shut off the current at the switch before connecting or disconnecting an electrical device, but every teacher knows that this does not insure that he will do it. We need to make many observation records of his procedure. The teacher should attempt to discover whether knowledge is functioning. Here, again, if parents understand what the school is attempting to accomplish and are cooperating sympathetically, their reports serve as a useful check.

The development of social attitudes and appreciations does not lend itself readily to measurement, but something may be expected from the many efforts now being directed along this line. The essay type of test, although subjective and time consuming, is often revealing. Observation is a valuable instrument here, especially if the teacher keeps attitude and behavior records for future comparison. When an experience is provided through

which the teacher hopes to develop social attitudes and appreciations, initial and end records of the child's reactions should be made to discover changes.

The development of scientific attitudes and habits of procedure must be judged in as many life situations as possible, as they are somewhat specific. A child may learn to proceed in a scientific manner in one situation and fail to do so when he encounters a different problem. It is to be hoped that tests of scientific attitudes and procedures will be developed for the many common problems of living. At present, the teacher must depend largely upon her observations of the children's reactions. It has proved helpful to record with some suitable symbol every evidence of scientific procedure on the part of each pupil and to note whether or not these tendencies increase.

CHAPTER VII

PREPARING TO TEACH ELEMENTARY SCIENCE

The Elementary Field of Service

A new deal is in prospect for the elementary-school children of America. Rare is the adult who was taught in these grades by a college graduate trained especially for the elementary field. It was not considered necessary to carry on any great amount of advanced study in order to teach elementary subject matter. The only qualification considered essential was a desirable personality. One well-known supervisor half earnestly remarked that graduates of the two-year normal course chose the primary grades if they had personality, the upper grades if they had ability, and the intermediate grades if they had neither. Most college graduates sought positions in the high-school field where salaries and prestige were greater. Those who gravitated into the elementary grades were seldom definitely trained for this field. Today the situation is rapidly being changed. Requirements for the elementary field are being raised. Teaching in the elementary school is coming to be considered no less worthy or important than teaching in the secondary school. In increasing numbers students in teacher-training institutions are pursuing their chosen field of elementary education throughout the four years of preparation. Children are beginning to experience the stimulation and joy of working with professionally trained teachers.

The elevation of the elementary teaching field is due to various factors, partly economic and partly professional. The over-supply of teachers able to meet the existing low standards and the reduction in the number of teaching positions as a retrenchment measure have increased competition and caused many teachers to secure more training. A more constant cause is to be found in the development of educational psychology and philosophy which have tended to emphasize the importance of training in the earlier years and the professional character of teaching at all levels. Some cities have adopted the same basic

salary schedule for equal training and experience throughout the school system. Whatever the causes, it is extremely significant that elementary teaching is on its way to becoming a profession. Perhaps it is not too much to hope that in a few years all elementary teachers entering the service will have earned a professional degree in the field in which they are to serve. We can also look forward to redirection and enrichment in the field of teacher training.

General Professional Training

Certain phases of general professional training are of paramount importance to the teacher in the changing elementary schools. Perhaps under the stimulus of an instructor of vision, the prospective teacher may acquire the vital educational philosophy of the new schools in almost any of the courses now offered in the field of education. However, certain experiences seem especially suited to develop the professional outlook rather than merely the skilled-work viewpoint. One of these is a challenging course in developmental psychology. Course titles vary with institutions. In some institutions this experience is to be had in a course in child psychology; in others, in genetic psychology. If such a course is not required of all elementary teachers, the student should make the necessary inquiries to insure that she includes it in her program. Another invaluable experience is a stimulating course in the aims and the educational philosophy of the current movements in education. The prospective teacher is now ready to participate in a course devoted to a critical study of the curriculum as a composite of the experiences and interactions for promoting child development rather than a body of facts to be learned. A broad course in appraising the results of teaching is justified to prevent the prevalent misuse and unfortunate effects resulting from inadequate knowledge of measurement as well as by the positive contribution that such a study can make. Study of method is of great value, although the placing of greater stress on minor techniques than on major procedures has possibly emphasized the skilled, but blind, worker aspect of teaching. The emergent experience for the prospective teacher is professional participation in a vital elementary teaching center where child development is fostered and studied. Fortunate is the teacher whose so-called practice teaching or interneship is spent in such a thrilling

enterprise. It is likely to mean for her a dedication to a professional level of service. The student-teaching phase of professional training is capable of great harm as well as great benefit. Habits, ideals, and attitudes toward teaching are crystallizing now. It would seem almost better that the teacher enter her own schoolroom, where she is to have complete responsibility, lacking student-teaching experience, but with the stimulating outlooks gained in her other professional courses, than to have her enthusiasms smothered in a traditional practice center where followership and conformity are imposed.

Training in the Field of Science

One of the handicaps in making science effective in the elementary school has been the teacher's lack of training in this field. So long as the subject was regarded as incidental in the elementary program, there was little attempt to prepare teachers in science. Now that it has become a regularly scheduled subject in some elementary schools and an important part of the integrated program in others, teachers and teacher-training institutions must make as definite preparation in science as in any other field.

In planning the special training in science needed for elementary teaching, it is necessary to take into consideration previous training. Most students entering upon professional training have studied general science in the junior high school. Many have studied one or more of the special sciences in the senior high school. It seems to be a growing practice among colleges and universities to require a survey course in science of all freshmen students. We may expect, therefore, that practically all students will have some science background at the time that they enter upon professional training. However, there will be much more variation in their preparation in this field than, for example, in English which is usually required in every year of general training. This means that the program of study of each prospective elementary teacher must be planned to meet her needs. It is possible to do this in consultation with an adviser, using as a basis a general outline of the phases of scientific experience most essential for elementary teaching, the student's previous records, and her achievement scores on a comprehensive examination covering these needed phases of

science. Marked deficiencies in preparation can then be removed through elective study in the fields of science in which the student is most lacking.

Analysis of some of the newer elementary courses of study indicates that teachers need training in a wide range of science experiences. More than a theoretical overview, though not necessarily an intensive knowledge of each field, is essential. Certain phases of astronomy, meteorology, physiography, geology, elementary agriculture, physics, chemistry, botany, bacteriology, hygiene, zoology, and entomology are needed; but it does not follow in all cases that the traditional college courses in these fields provide a satisfactory foundation for elementary teaching. In general, courses that deal with the relations of the science to our daily living and proceed through our common experiences are most useful to the teacher. The investigation[1] carried on by a committee on teacher training appointed by the National Association for Research in Science Teaching indicates that relatively little has been accomplished toward professionalizing subject-matter courses in science. The alternative to adequate courses in the various contributing sciences is a somewhat professionalized general course in science covering the phases of the various sciences needed in elementary teaching, sometimes designated as science for the elementary school. The advantage of such a course is the applicability of the material studied. The disadvantage is the inadequacy of such a background.

Considerable progress is being made in constructing curriculums to prepare elementary teachers. The high-school teacher is a special teacher in certain chosen fields. The elementary teacher is essentially a general teacher. The system of major and minor fields of study, which possibly is suited to the preparation of secondary teachers, is distinctly unsuited to the training of teachers for the elementary field. The practice of distributing the student's time somewhat equally among the various fields, a practice that seems to be gaining in favor in training elementary teachers, makes possible reasonably adequate preparation in all subject fields. Where this plan is followed and suitable courses are provided, elementary teachers are fairly well trained in science.

[1] HURD, A. W., "An Analysis of Some Professionalized Subject Matter Courses in Science in Teacher Training Institutions," *Science Education*, 17: 277–280, December, 1933.

Methods Courses in Elementary Science

There is, perhaps, more reason for a course in the methods of teaching science than in the teaching of any other elementary subject. Science has only so recently received recognition in the elementary school that teachers are at a loss how to proceed and quite hesitant to undertake anything very ambitious in the new field. There are, moreover, many problems concerning materials in science teaching as well as the usual matters dealt with in special-methods courses. Many teacher-training institutions are offering such a course. Although course titles vary greatly, we shall use the more comprehensive title—the teaching of science—in this discussion.

The course in the teaching of science ought naturally to follow most of the background courses in science and the general professional training. It should precede the teaching practice. Administrative considerations sometimes make it rather difficult to follow this order in all cases. However, for the good of the training-school children as well as that of the prospective teacher, students should not be assigned to student teaching in a newly organized field such as elementary science without adequate preparation.

There are so many things to be done to prepare for teaching in this new field that one quarter seems all too brief, although that is all that can ordinarily be allotted to the course in the teaching of elementary science. The instructor and students must, therefore, evaluate the many possible enterprises that might be undertaken in such a course and direct their efforts into those that seem most fruitful. For one thing, this means omitting many of the matters of technique that are covered in general education courses. A recently suggested outline for a course in the teaching of science consisted of some thirty or more topics concerning method. To divide the time between so many undertakings would be likely to result in a very superficial discussion of each and largely to defeat the purpose of the course.

The first major experience unit of the course should be to work out as helpful a statement as possible of the aims of elementary science teaching. The statements of aims should be clear and full enough to serve as goals for the succeeding units. The second experience may well be to consider the merits of the various general methods of teaching for the accomplishment

of the goals that have been established. Evaluation of methods is pertinent and significant only in connection with the outcomes we wish to accomplish. This should be borne in mind by the class when examining experimental evidence concerning the relative values of different methods. The third unit of the course may be devoted to planning suitable experiences to accomplish the aims decided upon. The members of the class should carry out many of these undertakings as if they were elementary pupils and discuss and evaluate them from the standpoint of a teacher. The experiences should be analyzed for their outcomes and contributing learnings. It will prove of great value to follow or accompany this unit with a study of the state course of study or other syllabus in elementary science that the teachers will be expected to use. Effort should be made to translate the course of study into virile experiences calculated to accomplish the aims of science teaching. The next unit may deal with materials of instruction. A list of simple materials needed in carrying out the experiences planned in connection with the course of study should be compiled. The class should attempt to reduce the list to be purchased to a minimum by substituting simple materials which can be secured without cost. It is a good plan to compile a minimum list and a desirable list to work toward. Some experience in constructing simple equipment is in place. Students will desire to record sources from which materials can be obtained, to examine catalogues of science equipment, etc. Part of the unit should be devoted to examining and evaluating reading materials, pictures, and other supplementary materials for enrichment. There may be a unit on appraising results in elementary science. If time permits, there are many other units of experience that merit consideration in the teaching of a science course. Throughout the course it is desirable to devote some time to observation and discussion of science work in the training school.

Training in Service

Few of the great army of elementary teachers now in service have had training for their work in elementary science that even approaches that described in the preceding paragraphs. Science, which has now become a more important part of their teaching duties, represents, therefore, one of the important fields where training in service is needed. The great increase in enrollment

in summer courses in the teaching of science is one of the best evidences that teachers feel the need of help in this field. Many more teachers are enrolled in extension courses in science and science education. Vinal[1] has recently called attention to the value of nature leadership courses in camp as training for teaching elementary science. Summer vacations can in this way be combined with science training. A number of plans for training teachers in service for their work in elementary science are employed at present. In Cleveland, teachers have gone from the science training center in the Doan School into other elementary schools in the city system. In Oakland, California, where science is more a part of the core of the curriculum than a scheduled subject, the science supervisor reports that science is permeating the work of the elementary school. The experiences of the various teaching groups have been assembled at the central office in the form of an extensive science teacher's manual for the assistance of all teachers in the system. This method of making available to teachers the unit experiences developed by others is one of the most hopeful devices for training teachers in service. Another extremely useful device is visitation. Administrators will do well to make it possible for all teachers to visit some outstanding elementary science teacher where they may gain something of the enthusiasm as well as suggestions for the work. The most important means is to enlist the teachers in the system, individual school, city, or county in developing the science program and to provide them with all possible available helps. Specialists may be called in to render assistance, but the teachers should take the initiative and feel the responsibility. If a science supervisor is employed, he should be engaged in training teachers in service and in supplying much needed assistance rather than in dictating and enforcing a set program.

[1] Vinal, William Gould, The Value of Nature Leadership in Camp As Training for the Teaching of Elementary Science, *Science Education*, 19: 1: 16–19, February, 1935.

CHAPTER VIII

RESEARCH CONTRIBUTIONS AND NEEDED STUDIES IN THE FIELD OF ELEMENTARY SCIENCE EDUCATION

What Research Is Meaning in Science Teaching

Wherever the spirit of research enters into any field of human endeavor, it acts as a decided stimulus. A challenging attitude develops. Assumptions, practices, and even basic philosophies of long standing are subjected to critical study and evaluation. Almost inevitably critical study leads to discovery, and eventually to wide recognition, of inadequacies and weaknesses in our concepts and practices. Interest increases, analytical discussion ensues, and a general reconsideration of philosophies, goals, and practices leads to a certain amount of redirection of effort. Research points out new possibilities, and an aroused group of workers extends the studies. New movements arise in the field, and the countless resulting interactions bring about a gradual change in points of view and in procedures. The early researches are shown, in the light of the results of subsequent studies and of changed and broadened philosophies, to possess certain limitations due to failure to take into consideration all of the factors. The virgin studies in the field are criticized and seldom fully credited, though they wakened our slumbering minds from the tranquillity of tradition. Should subsequent studies even reverse some of the earlier findings, these pioneer efforts have rendered important service in stimulating further progress. Other studies are undertaken along newly visioned hopeful lines. The old order can no longer continue unchanged.

This process is being enacted in science education at the present time. Although the methods of research have only recently been applied in this field of science, the order of progressive change and some of the results are already evident. From the elementary school through the college the present order of science teaching is being questioned. The traditional tranquillity is gone. The outlook has changed from a relatively static to a

dynamic one. Interest in the improvement of science teaching has increased immeasurably. Guiding philosophies are being altered and clarified. Vague aims are taking the form of definite goals. Content is being radically changed in the light of these goals. Teaching procedures are being evaluated. Publication has been stimulated. Better texts and enriched syllabi are appearing. One of the greatest values lies in the changing attitude of teachers. We are witnessing the gradual disappearance of the teacher who is, figuratively speaking, the "blind leader of the blind." The changes taking place in science teaching are due in part to other factors than the stimulus of research, but its influence is a very important one. The researches are at present limited in scope, and the findings are to be regarded as tentative. There can be no question, however, that they are markedly influencing science teaching.

Research Achievements in Elementary Science Education

Research in science teaching is a recent development. Only within the last two decades has it become a widespread movement. More investigations have been carried on at the secondary than at either the elementary or the college level. In certain respects, notably in methods of instruction, progress of research has been much slower in the elementary science field. On the other hand, many of the interest studies have appeared in this field. In the analysis of objectives and the approach to scientific construction of the science curriculum, researches at the elementary level have exerted marked influence on science education generally.

It is not our purpose here to review all of the researches in the elementary science field. This has been done for most of the published studies,[1] and further work along this line is being carried on by the Committee on Elementary Science of the National Association for Research in Science Teaching. Rather it is our purpose here to consider the progress that has been made

[1] For a more systematic report of the studies in elementary science education the reader is referred to two volumes by Francis D. Curtis, "A Digest of Investigations in the Teaching of Science" and "Second Digest of Investigations in the Teaching of Science," Philadelphia: P. Blakiston's Son & Company, 1926, 1931. Martin L. Robertson has summarized the principal studies in an article entitled, "A Review and Evaluation of the Curricular Studies Pertaining to Elementary Science," *Science Education*, April, 1934.

through research in order that we may see what basis for teaching practice the findings offer. We shall, also, then be better able to define some of the unsolved problems for future study.

1. *Studies of Children's Science Interests.* Many of the earlier researches in the field were attempts to discover the knowledge and interests that children possessed as a basis for the nature study program. This line of investigation dates back at least to the studies of Bartholomai[1] and of Longe[1] in 1870. These investigations and that of G. Stanley Hall[1] in 1880 were concerned with the knowledge children possessed at the time they entered school. Although there is little evidence that the investigations affected the practice of primary teaching generally, perhaps there is in these studies a suggestion worthy of consideration by all teachers today. They contain the germ of our present pretests.

Early in the present century, Trafton undertook to discover the nature knowledge and interests of fourth-, fifth-, sixth-, and seventh-grade children in the Passaic, New Jersey, schools.[2] Libby's study,[3] part of which was concerned with nature knowledge possessed by elementary children, appeared in 1910. After this time the emphasis in this line of investigation shifted from canvassing and recording the knowledge children possess to discovering their interests.

Both experimental techniques and analyses of children's questions and statements have been employed. Mau submitted two series, each consisting of an animal, a physical object, and a plant, to about 2000 pupils in the kindergarten and first three grades, to discover which the children preferred.[4] Finley also presented such a series to 827 pupils of the third to the eighth grades.[5] To study the nature of children's interests, he sub-

[1] HILLMAN, JAMES E., "Some Aspects of Science in the Elementary Schools," Contributions to Education No. 14, Nashville, Tennessee: George Peabody College for Teachers, 1924, Part I.

[2] TRAFTON, GILBERT H., Children's Interests in Nature Materials, reprinted in *The Nature Study Review*, 9: 150–160, September, 1913.

[3] LIBBY, WALTER, The Contents of Children's Minds, *Pedagogical Seminar*, 18: 242–272, October, 1910.

[4] MAU, LAURA EMILY, Some Experiments with Regard to the Relative Interests of Children in Physical and Biological Nature Materials in the Kindergarten and Primary Grades, *The Nature Study Review*, 8: 285–291, November, 1912.

[5] FINLEY, CHARLES W., Some Studies of Children's Interests in Science Materials, *School Science and Mathematics*, 21: 1–24, January, 1921.

mitted a mud puppy to 1716 pupils in the first to the eighth grades and analyzed their questions and a number of their compositions written about the animal. In 1912, Downing published a study[1] of children's interests in nature materials based on analysis of 295 observations and 447 questions submitted to *St. Nicholas Magazine* by 742 boys and girls averaging about twelve years of age. Palmer's studies were of similar nature and much more extensive. Through the well-known *Cornell Rural School Leaflet* he requested that teachers send in nature questions asked by pupils. In 1922 appeared an analysis[2] of the first 500 questions received, and in succeeding years additional studies[3] based on many thousands of questions submitted over a period of time by more than 7000 teachers. As one basis for textbook construction, Washbourne[4] allowed children of the fifth to the eighth grades to ask any questions in science that they wished to have answered. As one of several techniques employed in developing a course of study in elementary science, Craig[5] asked the children of grades one to eight in a group of widely distributed city and rural schools to write (grades one and two reported orally) the questions in science and nature study that had interested them most and that they desired to have explained. Stevenson[6] used a combination of methods to discover which type of science materials possesses the greatest appeal to children

[1] Downing, Elliott Rowland, Children's Interest in Nature Materials, *The Nature Study Review*, 8: 334–338, December, 1912. Summarized in the Third *Yearbook* of the Department of Superintendence of the National Education Association and in Francis D. Curtis, "A Digest of Investigations in the Teaching of Science," Philadelphia: P. Blakiston's Son & Company, 1926, pp. 129–131.

[2] The reader is referred to summaries by E. Lawrence Palmer and others in the September numbers of the *Cornell Rural School Leaflet* for the years 1922 to 1929 inclusive or to the abstracts of these summaries which appeared in the two digests of "Investigations in the Teaching of Science" by Francis D. Curtis.

[3] *Op. cit.*

[4] Washbourne, Carleton W., "Scientific Method in the Construction of School Textbooks," Yonkers-on-Hudson, New York: World Book Company. (No publication date given.)

[5] Craig, Gerald S., "Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School," Contributions to Education No. 276, New York: Teachers College, Columbia University, 1927.

[6] Stevenson, Elmo N., Children's Nature Interests, *Elementary School Journal*, 5: 276–284, December, 1931.

in the fourth to the sixth grades. His methods involved preference ratings by pupils, records of the numbers of pupils attracted to the tables on which the different types of science materials were arranged, and analyses of pupils' questions and compositions. Mahoney also studied pupils' questions[1] to discover the science interests of children in the fourth, fifth, and sixth grades. In order to detect seasonal science interests, an attempt has recently been made at the Doan School in Cleveland, Ohio, to rank children's interests three times during the year—in March, June, and December.[2]

It is interesting to compare the results and conclusions arrived at through the various studies of children's science interests. There is no doubt that these studies have stimulated interest in the child and the problems of education. One may reasonably question whether or not the investigations have established conclusions that may be accepted as bases of educational practice. Many inferences have been drawn from these studies—more than the studies now seem to warrant—not all of which are in agreement. The greatest weight of evidence has accumulated in support of the conclusion that children are more interested in animals than in plants and matters of physical science. Certainly the results of many studies agree in bearing out this conclusion. However, the recent study of seasonal science interests of children in grades three to six at the Doan School showed without exception the following order of interests: physical science, animals, plants. That investigation also tended to indicate that the children's preferences can be influenced considerably by well-planned activities in any field. Slavson and Speer question the validity of the "object-question" method of discovering children's interests, pointing out various limitations which they consider inherent in this procedure. They base their conclusions largely on observations of the tendencies of pupils in free-activity schools and other situations where the children were free to work with plants, animals, or physical science materials of various types as they chose to do. As a result of these

[1] MAHONEY, HELEN M., "A Study of the Scientific Interests of the Fourth, Fifth, and Sixth Grade Children of Flint, Michigan," unpublished Master's thesis, University of Michigan, 1933.

[2] BURGESS, ANNA E., The Curriculum School as a Method of Building a Course of Study in Elementary Science, *Science Education*, 18: 216–221, December, 1934.

experiences, they conclude that physical science provides many more challenging interests for young children than does biological science. Although they recognize the value of plants and animals in other phases of the development of young children, they do not consider them valuable as science materials.

> Animals, including insects, are of great importance to the general development of the child. Hence a scientific equipment designed to provide such development should include them, as well as materials of the physical sciences. But we have indicated sufficiently that few truly scientific possibilities are offered to young children by biological materials—animals or plants. These developments which engage the mental processes of investigation and construction, which are the essentials of science to the young child, are not possible with such materials.[1]

It is not likely that all workers will agree with this seemingly extreme statement. Slavson and Speer report the results of their observations in a general manner but do not show tabulated data. Their method seems to possess the advantage of permitting study of children's continuing rather than their transient interests under more natural conditions. Two limitations of the method ought, however, to be noted. It is very difficult to find or to maintain suitable conditions for the experiment uninfluenced by teachers, administrative officers, or local interest. Certainly such opportunities are rare even in the most progressive schools. In the second place, as Slavson and Speer point out, pupils may follow a leader. The number engaged day after day in any of the possible workrooms may be a measure, in part at least, of social preference rather than scientific interest. These authors have, however, contributed a fresh point of view in the study of children's science interests which must be taken into consideration.

Some unpublished investigations by the writer may throw light on the lack of agreement obtained in certain of the studies to which reference has been made in this discussion. On the basis of stenographic reports of the undirected remarks and activities of children allowed to group undisturbed about a table on which a number of species of animals were placed, the conclusion was reached that the child's interest is first of all in himself, his own acts, and his relations with his associates. In

[1] SLAVSON, S. R., and ROBERT K. SPEER, "Science in the New Education," New York: Prentice-Hall, Inc., 1934, pp. 126–127.

every grade from the kindergarten through the eighth, more than half of the remarks made by the children concerned themselves, as judged by the use of names and personal pronouns. The experiment was repeated using physical objects and plants instead of live animals with similar results.

It seems likely that the child is primarily interested in himself and in his social relations; secondarily and indirectly, in objects, whether animal, plant, or inanimate. His interest is probably proportional to the possibilities that the objects suggest to him for self-expression or for interaction with his associates. The lack of activity, especially of active response to him, on the part of plants thus restricts their appeal to the child unless he engages in growing them or carries on other activities involving them. Thus, at the Doan School,[1] a marked rise in the percentage of pupils most interested in plant life occurred when the use of a microscope and certain experiments were introduced. The situation with reference to interest in physical objects is probably similar. There can be no doubt as to the very great interest of children in manipulating toys, yet many physical objects attract little attention unless the child contemplates manipulating them or employing them in his social relationships. In the writer's experiments with children's interests in physical objects, the percentage of remarks that concerned manipulation ranged from 68 to 77. No lessening of manipulative interest was shown from the kindergarten throughout the elementary school.

Numerous tentative conclusions have been advanced with reference to the nature and order of appearance of children's science interests, but the results of the various studies are somewhat contradictory. It is probably too early to attempt to outline with any degree of assurance the normal order of development of children's interests in the different aspects of scientific study, if, indeed, there be any such typical sequence. Certain basic urges are evidently biological and are unquestionably associated with stages in physiological development, but, on the whole, it is probable that interests are acquired and may, therefore, be directed. Some evidence of sex differences in children's nature interests seems to have been obtained in several of the investigations. Boys seem to be more interested in simple mechanics than are girls. Some sex differences in emphasis of interest probably exist even among young children, but to what

[1] *Op. cit.*

extent they are due to inherent biological dissimilarity, on the one hand, or to social influence, on the other, is unknown.

2. *Studies of Children's Ability to Comprehend the Principles of Science.* It is obvious that at least a general understanding of children's ability to comprehend the principles of science is essential to progress in the field of elementary science instruction. A very common view in the early development of the field held that the child mind is not sufficiently developed at the elementary level to comprehend principles. Hence, it was deemed best to defer the study of scientific principles until the high-school years. Webb's findings[1] with reference to the abilities of children in grades five to eight to understand and apply principles of science in general bore out this contention. He concluded that:

> Real principles of science are not assimilated by children of the fifth grade and below; physiology and physiography are appropriate in the sixth grade; biology, and possibly physics, may be successfully taught in the seventh grade; physics can be assimilated in the eighth grade; but the laws and phenomena of chemistry seem unsuited to any grade.

However, it should be noted that Webb studied the ability of children to comprehend science principles through reading a direct statement setting forth the facts and principles of the test topic. Had he provided a series of experiences calculated to manifest these principles, and had he extended the learning period to more nearly approximate a normal teaching situation, it is possible that the results might have been different.

Hillman used a different procedure but arrived at conclusions agreeing, in general, with those of Webb. He first compiled a list of topics in nature study and science by examining a sampling of courses of study. He then formulated questions based on the topics that were common to several courses, the number of questions on each topic varying with the representation of the topic in the courses of study, and secured the responses of over 14,000 children to these questions. Comparing his findings with those obtained by Webb, he states:

> According to Webb's study, an understanding of representative scientific principles cannot be had below the sixth grade. Is the knowledge which children have in agreement with that general conclusion? If the

[1] WEBB, HANOR A., "General Science Instruction in the Grades": Contributions to Education No. 4, Nashville, Tennessee: George Peabody College for Teachers, 1921, Part II.

interpretations of scientific principles in the two studies are in agreement, the results in this study show that children know little about scientific principles, particularly below the sixth grade.

The kind of knowledge which children have of elementary science is largely of an observational and factual type, such as "what is," "name," and "tell about." It is the kind of knowledge which would be acquired incidentally, in the course of normal experience, with little or no regard to systematic classroom instruction.[1]

Examination of the 228 questions asked by Hillman reveals that few of them were designed to test understanding of scientific principles. Those which did not call for enumeration or statement of specific facts were, with few exceptions, general or subjective. His study did reveal a rather surprising lack of acquaintance on the part of the children with the science materials listed in the courses of study. However, without knowing what attempts were made to teach these facts and principles, it would be decidedly unsafe to conclude from the evidence obtained by Hillman that children are unable to comprehend scientific principles.

Even before this time, experimental evidence of children's ability to profit from science experiences was beginning to appear. Meister[2] attempted to compare the relative educational values of science play units with those of classroom teaching covering the same subject matter and employing apparatus, demonstrations, class discussions, pupil reports, home assignments, reviews, notebook work, and quizzes. His experiments extended over a period of two years but were limited to four groups of about twenty-five boys each in the fifth and sixth grades. The groups were of approximately equal mental age and intelligence quotient. Group A had both lessons and play; group B had only lessons; group C had only play; group D had neither. The experimenter made no attempt to instruct the play groups. The results were tested by essay-type tests, written explanations following twenty demonstrations by the experimenter, tests of ability to perform experiments

[1] HILLMAN, JAMES ELGAN, "Some Aspects of Science in the Elementary Schools," Contributions to Education No. 14, p. 64, Nashville, Tennessee: George Peabody College for Teachers, 1924.

[2] MEISTER, MORRIS, "The Educational Values of Certain After-school Materials and Activities in Science," Doctor's dissertation, Teachers College, Columbia University. Digests appeared under the title, The Educational Value of Scientific Toys, in *School Science and Mathematics*, December, 1922, and in the *General Science Quarterly*, March, 1923.

based on the units of study, and tests of constructive ability. The tests covered material common to the play units and the lessons. The results, with all due consideration of the limitations of the experiment, are exceedingly interesting. Two of Meister's[1] conclusions were that "Extra-curricular activities in science make for almost as good a knowledge and appreciation of environmental phenomena as do curricular activities" and "boys who participate in both curricular and extra-curricular activities excell all others. . . ." He also states that the extracurricular activities encourage originality and inventiveness and result in better constructive ability. Perhaps the most educationally significant conclusion reached by Meister is that "the chief characteristic about a boy who succeeds in overcoming a difficulty is that he almost always finds a new problem arising out of the old one."

Although Robertson's investigation was carried on for the purpose of comparing the relative effectiveness of two methods of teaching elementary science in the fifth grade, one of his concomitant conclusions dealt with the ability of pupils to comprehend biological and physical science principles. He selected six units from Craig's "Tentative Course of Study in Elementary Science." These were the causes of the phases of the moon, ice formation, magnetism, the migration of animals, the hibernation of animals, and the change in form and appearance of animals and insects. The subjects were two closely equated groups of fifth-grade pupils in the Oxford School at Dearborn, Michigan—about sixty in all. On the basis of the scores on initial tests; delayed-recall tests; and unit tests involving completion, matching, and modified true-false types, Robertson concluded that "the subject-matter materials used in this investigation were entirely practical for use with these fifth grade pupils by either method."[2]

Haupt[3] attempted experimentally to test the application of the philosophy that science teaching on all grade levels should be directed toward understanding of certain scientific principles,

[1] *Op. cit.*

[2] ROBERTSON, MARTIN L., An Investigation of the Relative Effectiveness of the Two Methods of Teaching Elementary Science, *Science Education*, 16: 182–187, February, 1932.

[3] HAUPT, G. W., "Experimental Application of a Philosophy of Science Teaching in an Elementary School," Contributions to Education No. 633, New York: Teachers College, Columbia University, 1935. A brief article

generalizations, or objectives. He limited instruction to certain effects of light, the understanding of which is essential to comprehension of the general principle of the transfer of energy. Children in grades one to six were tested before and after instruction Haupt interpreted the results as indicating that "the mental processes of interpretation, reasoning, and generalization are necessitated by the use of this type of objective," and states that "when this particular objective was used with these children there was interpretation and generalization on every grade level." He found that children in the upper elementary grades synthesized more learning elements in one complex explanatory statement than did primary-grade pupils and tended toward a more abstract conception of the objective. He interpreted these differences as offering a suggestive basis for differentiation of instruction on different grade levels. His data are limited and not altogether convincing. Many of the children's generalizations are classified as neither correct nor wrong but vague. However, his study is an interesting one and opens a field almost unlimited in possibilities for future experimentation.

The view that science teaching even on the elementary level should be directed toward comprehension of scientific principles and other concomitant outcomes has not been universally accepted. Indeed, it is one of the chief matters of discussion and study in the elementary science field at the present time. Directing science work toward understanding principles, which, in turn, are the essential contributing elements for broader generalizations, finds support on the ground that it will give purpose to otherwise aimless and desultory science teaching, guide us in the training of teachers, and serve as a basis for critical evaluation and much needed revision of syllabi. On the other hand, the question has been raised as to whether such a program of science education is psychologically sound. A number of workers have expressed the view that elementary pupils are absorbed in attaining emotional satisfactions, that generalization is a somewhat unnatural process as this period, and that forcing processes must be resorted to in attempting to develop generalizations at this age with resulting outcomes of little value in child development. We need to know whether the failure of children

---

under the same title appeared in *Science Education*, 18: 34–238, December, 1934.

to generalize in science is due primarily to lack of this power or tendency or simply to want of suitable and sufficient experience basis for generalizing.

The writer carried on a series of six experiments[1] in the attempt to discover whether children generalize readily without explanation by the teacher. In each experiment a period of eight minutes was devoted to directed play or demonstrations designed to provide a series of experiences each of which manifested the same principle. At the close of the experience period, the experimenter asked a single question calculated to call forth a statement of the principle common to all of the experiences. Later, one or more concrete application questions were asked. Children in the kindergarten and first two grades reported orally to observers stationed about the room; others wrote their responses. The subjects were about 525 pupils in the training school of the Saint Cloud State Teachers College in Minnesota and two public elementary schools. The results indicated that many children in the upper primary-, intermediate-, and junior high-school grades are capable of generalizing on the limited experience basis provided in the experiment. While the experiments did not prove that most pupils in the kindergarten and lower primary grades could not generalize if a more adequate and extended experience basis were provided, the data, together with the evident obsession manifested by these children for obtaining emotional satisfaction, did suggest that early childhood is preeminently a period for satisfying interactions. The superiority of junior high-school pupils over those in intermediate grades in the matter of formulating and applying generalizations was little more than might reasonably be accounted for on the basis of added experience. The scores of pupils in the "opportunity" or subnormal classes suggested the hypothesis that factors other than lack of ability to generalize entered into their classification, but the number of subjects was too small to make the results of particular significance.

The investigations in this phase of research in science education can hardly be said to have yielded the desired information. Comprehension is probably an evolution. There are many degrees of comprehension. There is considerable evidence that elementary-school children are able to comprehend to at least a

[1] Croxton, W. C., Pupils' Ability to Generalize, *School Science and Mathematics*. 36: 627–634. June. 1936.

limited degree many of the principles of science. The extent to which science teaching may profitably be directed toward the comprehension of these principles in the successive grades of the elementary school has not been fully determined. However, the problem is a very important one, and many future studies in this field may be expected.

3. *Studies of the Status of Science in Elementary Schools.* There has been a strong tendency in the schools toward conformity in curricular matters. We find what the majority of schools are doing as a means of discovering whether we are following the right course. From time to time, analyses of the science content of elementary courses of study have appeared either as separate studies or as phases of more extensive investigations. The purpose most frequently listed by these investigators was to discover whether the courses of study in elementary science revealed any common aims and content. This purpose has been reasonably well accomplished. With the exception of Patterson's[1] study, published in 1913, the findings of the investigations have rather generally agreed in showing considerable variation in content and aims. In fact, the notable lack of agreement in content and in definite aims was one of the conditions that helped to give rise to the new movement in elementary science education. Perhaps this is the greatest contribution that these studies have made. Such investigations involving analysis of courses of study result in numerous findings permitting of many specific conclusions. It is possible in this brief general treatise on science in the elementary school to refer only to certain of the findings which seem most significant.

Thompson[2] analyzed eighty-two courses of study published between 1915 and 1919 and prepared a list of topics most commonly treated in each grade. Although his work does not seem to have been published, such studies have a potential value in curriculum construction in suggesting materials to be considered.

Hillman's study[3] of the 1921–1922 courses of study of fifteen states, nineteen cities, and two training schools revealed that

[1] PATTERSON, ALICE JEAN, The Present Status of Nature-study in the Elementary Schools, *The Nature Study Review*, 9: 239–244, November, 1913.

[2] THOMPSON, CLEM., "Science Materials Used in Instruction in the First Six Elementary Grades," Master's thesis, University of Chicago, 1920.

[3] HILLMAN, JAMES ELGAN, "Some Aspects of Science in the Elementary Schools," Contributions to Education No. 14, Nashville, Tennessee: George Peabody College for Teachers, 1924, Part II.

"there is, then, no general agreement as to the topics that make up the science of the elementary school." His findings that three-fourths of the work in plant life and animal life and more than one-half of the work on physical-chemical phenomena were scheduled for the first four grades must be interpreted in the light of the fact that agriculture and physiology were eliminated from his tables. The science work of the seventh and eighth grades in some courses of study at that time was centered about agriculture. Hillman did not end his study with analysis of the courses of study but proceeded to try to find out how much children knew about the matters listed in these courses. His findings in this respect have been discussed in the section of this chapter dealing with studies of children's ability to comprehend the principles of science.

Craig[1] made a rather extensive survey of "practices in the teaching of elementary school science." He analyzed a large number of courses of study, examined source books handbooks, and syllabi and interviewed teachers, supervisors, and administrators. He found decided lack of organization, a chaos of goals, neglect of important science content, and a generally disconnected and unbalanced program. His attempts to construct a science curriculum to remedy these conditions will be discussed in the next division of this chapter.

Few textbooks in elementary science have been available until recently. Studies of the status of science in the elementary schools have consequently been limited chiefly to analyses of courses of study. Elementary textbooks in health work having appeared much earlier, Strang[2] analyzed samples of these as well as courses of study in her attempt to discover the status of this phase of science work in the schools. She found a great diversity in the health material presented in the various grades as judged by the small sampling of courses of study and the textbooks in the field. She, moreover, states that "the list of most frequently mentioned items shows a preponderance of the indefinite, mean-

[1] Craig, Gerald S., "Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School," Contributions to Education No. 276, New York: Teachers College, Columbia University, 1927.

[2] Strang, Ruth, "Subject Matter in Health Education," Contributions to Education No. 222, New York: Teachers College, Columbia University, 1926.

ingless type of statement. . . . " The investigation by Cairns,[1] while it involved a somewhat different procedure, agrees, in general, with Strang's findings in indicating that "there is need for a better selection and a better organization of instructional content." Her study and that of Lerrigo[2] surveyed the field of health needs in such a way as to throw considerable light on the type of instruction needed in the schools.

Two other studies involving analyses of course-of-study content should be mentioned here, both for their added confirmation of the conclusions reached by other investigators and for the additional methods of approach which they utilized. Bagley and Kyte[3] not only analyzed all available county and city courses of study in California but, in addition, surveyed the literature of the field to discover the instructional status of elementary science. They found "little agreement either as to materials that should be included in such courses or as to methods of teaching; and an almost total lack of investigation regarding the essentials in elementary science." Mathis,[4] in her analysis of eleven courses of study in 1932, tabulated the aims, although she used the rather uncritical list of aims that appeared in the Fourth *Yearbook* of the Department of Superintendence of the National Education Association as a basis of classification. She also analyzed the courses of study for the principles and activities included at each grade level.

The analyses of courses of study reveal some of the inadequacies in the provision for elementary science. As a survey committee state in introducing their report:

> Nature study and elementary science have great vitality, for they continue in their widespread use under many methods, many types of content, and wide variation in training of those who teach. A syllabus

[1] CAIRNS, LAURA, "A Scientific Basis for Health Instruction in Public Schools," University of California Publications in Education, Vol. II, No. 5, pp. 339–434, Berkeley, California: The University of California Press, 1929.

[2] LERRIGO, MARION OLIVE, "Health Problem Sources," Contributions to Education No. 224, New York: Teachers College, Columbia University, 1926.

[3] BAGLEY, WILLIAM C., and GEORGE C. KYTE, "The California Curriculum Study," pp. 203–233, Berkeley, California: University of California Printing Office, 1926.

[4] MATHIS, ANNIE LOIS, "An Analysis of Recent Courses of Study in Elementary Science," Master's thesis, University of Chicago, 1932.

in any other field as lacking in generally convincing definition as has been true of this subject would probably have been dropped from the course of study long ago.[1]

Naturally, the results of such investigations cannot be taken as a measure of the effectiveness of elementary science instruction. Teachers do not always carry out the work as outlined in the course of study. Even where this is done, such investigations are not designed to show to what extent the child is able to profit by the instruction. We are probably safe in assuming that without adequate provision for elementary science in the courses of study, there is little likelihood that the subject is reasonably fulfilling its function in education. Palmer's extensive survey[2] of the status of nature and science training in the schools and of the provisions for the preparation of teachers in this field led him to suggest some needed changes. He secured information concerning the science work in the schools from state departments of education and from a large number of city superintendents. He also analyzed the offerings of higher institutions with respect to the training of science teachers. He found that:

> Requirements of the teaching of nature or science work by State Departments of Education does not guarantee general teaching of the work. . . . State outlines reported as mandatory for use on a state-wide basis are not necessarily followed except in rural schools. They are frequently written by those whose background of experience, interests, and training is essentially urban on an organization unsuitable for use in rural schools.

He also found that "recognition of courses in nature and science education as applied to elementary schools is not uniform in higher institutions of learning but these courses are demanding increased respect and support." He concluded that the courses offered in many higher institutions for training science teachers are inadequate and often inappropriate. There is little doubt that this is one of the most needed steps in improving the status of science work in the elementary schools.

[1] WELLER, FLORENCE, FLORENCE G. BILLIG, BEULAH CONOVER, JENNIE HALL, W. W. MCSPADDEN, CLARENCE M. PRUITT, and ROSE WYLER, A Survey of the Present Status of Elementary Science, *Science Education*, 17: 193–198, October, 1933.

[2] PALMER, E. LAWRENCE, "The Nature Almanac" Washington, D. C. The American Nature Association, 1930, pp. 148–277. A Nature Education Survey of the United States.

The survey of the status of elementary science reported in 1933 by Weller[1] and a committee of investigators, excerpts from the introduction of which were quoted in a preceding paragraph, revealed somewhat more encouraging conditions in the schools. The sampling consisted of one elementary school for every 200,000 population in Alabama, California, Colorado, Connecticut, Michigan, Minnesota, New York, and Texas. The committee that represented the states included in the study probably exercised more care in selecting representative schools and in securing reliable data than is usually employed in such studies. More than four-fifths of the schools reported that science is taught regularly, the average time devoted to the subject being about seventy-two minutes per week. Approximately three-fourths of the schools reported an increase in interest in science, in many cases quite marked, while only 4.1 per cent answered "No." Of the 21.5 per cent failing to report either way, 18.6 per cent did not teach science. Nearly three-fourths of the schools reporting followed the conventional organization with a room teacher for each grade. Only 4.1 per cent employed a special teacher of science. About one-fifth of the schools had a science classroom, and slightly more reported a science museum of some sort. The investigators do not include a full report of the courses of study in use, but such data as they do present indicate a strong tendency to construct local syllabi. The work was organized on a unit basis in over half of the schools. Many methods of instruction were reported, with the project method leading slightly. The suggestion which these investigators offer for improving the status of elementary science agrees with Palmer's recommendation. Referring to the training of teachers, they state: "It is in this aspect of elementary science that much needs to be done to strengthen the field."

4. *Studies Directly Concerned with Curriculum Construction.* Many of the investigations that we have been discussing might well be classed as curricular in nature. In addition, there have been a few direct attempts to apply the methods of research to the construction of the elementary science curriculum. Most notable of these was Craig's extensive pioneer study[2] in which he

[1] *Op. cit.*

[2] CRAIG, GERALD S., "Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School," Contributions to Education No. 276, New York: Teachers College, Columbia University, 1927.

employed a number of techniques in developing a course of study in elementary science. His survey of existing practices in the teaching of elementary science, together with the results of other studies of the status of science in the schools, having revealed a lack of organization and directive purpose, Craig set about constructing a more "functional" course in elementary science for the grades. His first step was to set up three criteria for the selection of objectives:

A. Certain objectives that are selected for elementary school science should conform to those scientific conceptions (1) which when understood greatly influence the thought reaction of the individual; and (2) which have modified thinking in many fields.

B. Certain objectives that are selected for elementary school science should conform to those goals (information, skills, and habits) in science that are important because of their function in establishing health, economy, and safety in private and public life.

C. Certain objectives that are selected for elementary school science should conform to those facts, principles, generalizations, and hypotheses of science which are essential to the interpretation of the natural phenomena which commonly challenge children.

He later added two other goals:

D. Acquaintance and identification of the environment.

E. General goals.

He obtained a set of more definite objectives which seemed to satisfy these five criteria by analyzing the volumes of *The Nature Study Review*, courses of study in elementary science, professional literature, and treatises on astronomy, biology, chemistry, geology, and physics. He submitted this set of objectives to twenty professors and instructors of science and education for criticism and suggestion. His next step was to submit the list of objectives to educated laymen for ranking as to their importance. He also evaluated the tentative objectives on the basis of 4354 children's questions, adding additional objectives suggested by the questions. The objectives for the course of study were then selected from those having high rank in the three evaluations. Craig then analyzed forty-nine treatises on science to obtain a list of central meanings which he checked against the final list of objectives. These central or "key meanings" he used in breaking the objectives up into themes or contributing elements. These elements were then assigned grade levels, those which

required simple observation or were basic to others being relegated to the lower grades. The course of study thus obtained[1] has been widely and justly credited with providing common objectives in science teaching for the coordination of the work in the various grades. It has served as a pattern for the construction of many syllabi and has influenced science teaching on all levels. Its greatest contribution is in the emphasis on broad concepts as goals of instruction in the initial criteria assumed at the outset of the study, an important point of view in science teaching which had not received the attention that it merits. Craig's methods were not new. Although each of these methods is open to certain criticisms because of its limitations, his procedure of checking the findings by various methods to reach an evaluation set a new standard in the field. It will be some time before Craig's conclusions find their place in an even more comprehensive solution of the problem, but it is reasonably safe to predict that they will exert a marked influence.

In 1930, Sowder undertook a check study[2] in which he attempted to follow Craig's methods as closely as possible. Some of his final list of objectives agree with those arrived at by Craig. In other items there is marked disagreement which the investigator attributed partly to differences in the "individualities" of the experimenters which "lead to differences in selection of source meanings" and in part to the composition and interests of the groups of pupils and laymen used as subjects in the investigations.

As previously stated, Robertson attempted to compare the relative effectiveness of two methods of teaching six of the units developed by Craig and concluded that "the subject-matter materials used in this investigation were entirely practical for use with these fifth-grade pupils by either method."[3] More

[1] Craig, Gerald S., "Tentative Course of Study in Elementary Science for Horace Mann School, Vol. I, grades 1 and 2; Vol. II, grades 3 and 4; Vol. III, grades 5 and 6," New York: Bureau of Publications, Teachers College, Columbia University, 1927.

[2] Sowder, W. J., "A Check Study of Gerald Craig's Paper on Certain Techniques Used in Developing a Course of Study in Science for the Horace Mann Elementary School," unpublished minor thesis, Cornell University, 1930.

[3] Robertson, Martin L., A Study of the Relative Effectiveness of Two Methods of Teaching Elementary Science, *Science Education*, 16: 182–187, February, 1932.

recently, Haupt[1] reported an experimental attempt to apply the philosophy of science teaching which holds that learning on all grade levels should be directed toward understanding of scientific principles or generalizations as objectives. His study covered a limited set of learnings concerned with light phenomena as illustrations of the principle of transfer of energy, but it is of special interest in curriculum construction in that the investigator attempted to study the nature of the learning and generalization at each elementary-grade level. This is a most important phase of research essential to progress in curriculum construction. The opportunity for further studies of this nature is almost unlimited, and the need is very great.

Another problem in developing a curriculum in accord with this philosophy of science teaching is the selection of a body of scientific principles to serve as unifying elements in instruction. Craig's studies, previously described, yielded a tentative list. The writer has called attention[2] to the need for cooperative action in formulating statements in the nature of distillates of scientific knowledge and concepts. Such concentrates might be very useful in researches in curriculum construction as well as in many other ways. Some of the statements in the list suggested in the Thirty-first *Yearbook* of the National Society for the Study of Education are in the nature of broad generalizations capable of widely influencing the outlook of humanity. Others, while they represent important principles or facts in science, seem much more limited. Such statements as "Light is a limiting factor in life" could be multiplied readily by changing the word light to water, temperature, etc. Likewise, other laws might be included along with "Liquid or gas pressure is exerted equally in all directions." No one will question the importance of these laws or principles. Attention is here called to the wide divergence in scope of statements and the large number of limited principles which might be included, only for the purpose of showing the occasion for extensive analysis as well as experimental research in this field. The list of generalizations suggested as one of the

[1] HAUPT, G. W., An Experimental Application of a Philosophy of Science Teaching in an Elementary School, *Science Education*, 18: 234–238, December, 1934.

[2] CROXTON, W. C., Scientific Concentrates, *Proceedings of the Minnesota State Academy of Science*, pp. 5–7, St. Paul, Minnesota: Academy of Science, April. 1936.

major aims of science teaching in a recent article by the writer[1] includes a considerable number of Craig's generalizations and is an attempt to formulate broad concepts as goals rather than limited statements of scientific laws. However, broad concepts can serve as immediate objectives only when they are broken into supporting principles and their contributing learnings.

In an investigation undertaken for the purpose of determining the principles of science suitable as goals of instruction in the elementary grades, Robertson[2] first proceeded to define a principle. This has been a matter of so much discussion that his criteria are quoted here.

The term *principle* as used in this study refers to a major generalization of science that conforms to the following criteria:

Criteria for a Principle

A. To be a principle, a statement must be a comprehensive generalization.

B. It must be true without exception within limitations specifically stated.

C. It must be a clear statement of a process or an interaction.

D. It must be capable of illustration so as to gain conviction.

E. It must not be a part of a larger principle.

F. It must not be a definition.

G. It must not deal with a specific substance or variety or with a limited group of substances or species.

A list of 243 principles was obtained through the combined judgments of three science teachers with the cooperation of subject-matter specialists. The sources considered by the jury were certain master's theses and published studies of the principles involved in general science, chemistry, physics, biology, and geology. This list of principles was then evaluated by fifteen teachers of elementary science, supervisors of elementary science teaching, and professors of the teaching of elementary science on the basis of their suitability to serve as goals of instruction in elementary science instruction. Each evaluator ranked the suitability of the principle on a five-point

[1] Croxton, W. C., Major Aims in Science Teaching, *Science Education*, 19: 149–152, December, 1935.

[2] Robertson, Martin L., The Selection of Science Principles Suitable as Goals of Instruction in the Elementary School, *Science Education*, 19: 1–4, February, 1935; 19: 65–70, April, 1935.

scale ranging from (1) not at all suited to (5) ideally suited. Robertson included in his final list all principles that received a median rating of 2.51 or higher. He found that "There is a wide range of opinion among these elementary science experts with respect to the suitability of the various principles." While his entire list will not be accepted by all workers, such lists do have a definite value as suggested material for curriculum construction.

Hurd[1] secured the judgments of sixty-six experienced workers in the field of science education on the importance of various criteria, plans, and features of organization of elementary- and secondary-school science courses. The judgments were in the form of ratings on a seven-point scale varying from (1) no importance to (7) great importance. Some difference of opinion was revealed, but the investigator found statistically significant consensus of opinion favoring organization "about major topics having large social implications" and an "in class program of assignment, study, discussion, reports, drill, recitation, explanation, demonstration, laboratory work, and the like." The criterion "to explain some scientific attitudes, and show how they affect man's thinking, (*e.g.*, open-mindedness, suspended judgment, etc.)" received the highest rating. Maintaining the organization of the developed sciences, limiting the work to accord with the facilities of the school in the way of equipment and teacher training, and "the traditional, conventional academic lesson-giving and lesson-learning scheme requiring home work" were all rated low in importance.

Another avenue of approach in curriculum construction, while not employing the controlled conditions of experimental research, is worthy of consideration. Controlled experiments are frequently of relatively short duration, and they often involve somewhat unnatural conditions. The collection of data under natural school conditions over a long period of time, adjustment and revision on the basis of evidence and experience, and the submission of these changes to trial in a large school system with its usual heterogeneous personnel is an important phase of curriculum research. For this reason such centers as Doan School in Cleveland are important. School experimentation with the curriculum is becoming increasingly common. Certain of the progressive schools have entirely discarded the predetermined course

[1] HURD, A. W., How Shall Science Instruction Be Organized?, *Science Education*, 18: 106–112, April, 1934.

of study. It remains for researchers to measure the results of these ventures in terms of their influences on the lives of children. There is a growing realization that knowledge does not insure its functioning in the lives of our pupils. We may expect, therefore, that curriculum research will follow the trend toward measurement of functional outcomes.

In every discussion of the improvement of teaching, whether from the standpoint of philosophy or of research, we always turn to the preparation of teachers. Therefore, it is not strange that the researches directed toward developing a curriculum centered about science generalizations as goals are paralleled by similar studies in the preparation of teachers. Billig[1] attempted to develop a technique for determining the content of such a professional course. Her study is interesting as a beginning of a line of research which is reasonably certain to call forth many more efforts.

5. *Method Studies.* It is interesting to speculate as to why so few method studies have appeared in the elementary science field, especially in view of the fact that this has been the favorite field of investigation at the secondary level. Perhaps the reason is to be found in the conditions that have prevailed in elementary science. The incidental place that the subject has held in school programs, the lack of established content and objectives, and the consequent widespread failure of the subject to fulfill any important role in education have tended to direct the attention of researchers toward a study of objectives and content. When a subject is finding its place in the program of studies, interest turns toward these phases. After that time a reasonable proportion of research effort may be expected to divert to the study of method. Moreover, it is usually conceded that teaching methods in most fields at the elementary level have been much superior on the whole to those employed in secondary schools. Attention has been focused on the child to a much larger extent in the elementary school. The content of secondary school science has largely come down from the colleges, and with it, all too often, has come the more formalized method of the college classroom. It is not strange, in view of these needs, that more studies of method have appeared

[1] Billig, Florence Grace, "A Technique for Developing Content for a Professional Course in Science for Teachers in Elementary Schools," Contributions to Education No. 397, New York: Teachers College, Columbia University, 1930.

in the secondary than in the elementary science field. The direction of research is often determined by the situation. Moreover, the total number of studies in the secondary field as well as the proportion devoted to method is much greater.

Of the few experimental studies of method in elementary science that have appeared, Meister's study[1] of the relative values of science play units and classroom teaching, referred to in an earlier part of this chapter, is the most interesting and significant. This experiment was described in the section devoted to studies of children's ability to comprehend the principles of science, and it is necessary here only to consider the possible significance of the findings. It will be recalled that the group having experience with play units but no individual or group instruction showed gains in knowledge almost equal to those made by the group receiving instruction involving apparatus, demonstrations, class discussions, pupil reports, home assignments, reviews, notebook work, and quizzes. Meister also concluded that the extracurricular or play-unit group showed superior gains in many other respects including originality, inventiveness, ability to fashion raw materials into usable things, and the discovery of new problems arising out of those undertaken. He further concluded that boys who had the benefit both of the play units and of the classroom teaching excelled all others. It is to be hoped that further experimentation along this line will be undertaken with large numbers of children in all grades of the elementary school and that as adequate measures of the outcomes as possible be devised. If future researches substantiate Meister's findings, it would seem that furnishing suitable science play units might solve some of the problems of providing for science experiences to accompany other instruction under the limitations of existing conditions in the schools. According to the observations of children's activities in free-choice schools reported by Slavson and Speer,[2] this would seem likely to be true, particularly for matters of physical science. In fact, their "search-discovery method" has much in common with Meister's play units.

Robertson's study of the relative effectiveness of two methods of teaching six units in elementary science has also been referred

[1] *Op. cit.*

[2] Slavson, S. R., and Robert K. Speer, "Science in the New Education," New York: Prentice-Hall, Inc., 1934, 384 pp.

to in another connection in this chapter.[1] He taught as nearly as possible the same content to two groups of fifth-grade children. He introduced the units in the same manner to both groups. One group then used the "story" prepared by the experimenter covering the subject matter of the unit and a guidance outline for study. The experimenter assisted the pupils as in any work period. The other group was taught by a developmental-discussion method. The test scores revealed little difference between the achievements of the two groups. Robertson concluded that the extra work entailed in preparing the study guides was not justified by the results obtained.

A number of schools are making use of radio broadcasting in their science work, but very little research work has been undertaken to determine the effectiveness of the methods employed. Harry A. Carpenter, specialist in science in the schools of Rochester, New York, where rather extensive use of this method has been made in the sixth, seventh, and eighth grades for a number of years, reports:[2]

> On the basis of evidence such as examination results, reports of science activities, individual and group experimentation, note-book work much of which is done in the home, our conclusion is that it is practicable and effective to provide science training by radio for all children who, because of certain limitations, cannot be instructed by science trained classroom teachers with suitable laboratory equipment available.

Carpenter also stresses other advantages of this method. He considers it a "powerful medium for the training of teachers in service" and an important agency for unifying administration, teacher, pupil, and parent in the educational process.

The use of the radio in directing and coordinating science instruction in the sixth grade has also been tried and studied in the schools of Cleveland, Ohio. As in Rochester, pauses are allowed for pupil response and a limited amount of activity during the broadcast. Melrose reports[3] a tabulation and analysis of the pupil reactions during five lessons broadcast in connection with a unit, "A Study of the Sky":

[1] *Op. cit.*

[2] CARPENTER, HARRY A., General Science in the Rochester Schools, *Proceedings of the Department of Science Instruction of the National Education Association*, 1935.

[3] MELROSE, MARY, Radio Lessons in Elementary Science, *School Science and Mathematics*, 36: 137–141, February, 1936.

Questions	97
Carrying out directions	33
Observations	30
Suggested activities	8
Games	4
Dramatizations	3
Total	175

Pupil participation during three lessons on nonflowering plants and the time in seconds devoted to each type were:

Questions	253
Experiments	226
Observations	185
Directions	92
Directions for the teacher	72
Total	828 seconds or 13.8 minutes

The total broadcast time for the three lessons was 42 minutes. Melrose's analysis showed that in both series of broadcasts analyzed, pupil participation occupied approximately one-third of the time. Tests administered at the end of each semester seemed to indicate a rather high degree of mastery of the subject matter by this method of instruction, although no comparative setup with control groups is reported.

Melrose also secured teachers' statements of the advantages and disadvantages of the method on the basis of their experience with it. Eight advantages are listed which are in general agreement with those advanced by Carpenter, although greater emphasis is placed on the facilitation of learning activities. The four disadvantages listed, aside from the problem of variable radio-reception conditions, are all concerned with inadequate provision for individual differences. There is no discussion as to whether the method tended toward emphasizing factual learning and following directions rather than pupil purposing and growth, outcomes that are difficult to measure. However, it should be noted that the broadcasts occupied only 15 of the 120 minutes devoted to science each week in the sixth grade. It is possible to devote the remaining time to educational procedures calculated to develop pupil initiative. In fact, the broadcasts may prove very valuable agencies for stimulating creative activity. It would seem that the use of the radio may be adapted to various

educational methods and that the nature of the broadcasts will depend upon the guiding philosophy until such time as research may prove or disprove the effectiveness of our procedures.

6. *Other Studies.* The research contributions to science education in the elementary field considered in the foregoing discussions are by no means the only ones. The aim has been to select enough studies for consideration to indicate the trends and the present status of research in this field. A number of other studies, some of which are unpublished, might have been included had space and time permitted. Only a few of these which represent other avenues of approach, or which employ somewhat different methods, will be referred to here. No attempt will be made to include the many investigations in the borderlands of elementary science education, some of which have significance in this field.

The growing tendency to consider acquiring information primarily a means toward desired functional or behavior outcomes is leading to attempts to measure such goals. Weller[1] conducted experiments in which the attention of certain groups of pupils in sixth-grade science was directed toward attitudes as well as toward factual knowledge. The pupils in these groups practiced drawing conclusions from consideration of much data. "Erroneous conceptions were deliberately brought up and discussed, and superstitions argued about." In comparison with the control groups, these classes averaged much higher, in general, on the written tests designed to measure attitudes and freedom from superstitions. On the other hand, Lichtenstein[2] found that stressing preference of outdoors to movies in connection with science teaching in the intermediate grades did not function in significantly changing behavior in this respect. He concluded that "until more crucial work in this field is produced, the modification of an attitude in teaching would appear to be rather a dubious procedure." There is a great need of research in the field of attitudes. Most of the attempts at measurement have depended upon pencil-and-paper reactions. It is doubtful whether these are valid indications of the functioning of attitudes in general behavior. While Lichtenstein and a few other investi-

[1] WELLER, FLORENCE, Attitudes and Skills in Elementary Science, *Science Education*, 17: 90–97, April, 1933.

[2] LICHTENSTEIN, ARTHUR, The Effect of Teaching Stress upon an Attitude, *Science Education*, 19: 73–75, April, 1935.

gators attempted to measure overt behavior, their efforts are too limited to serve as guidance.

Another research approach toward the improvement of elementary-science teaching is through the study of practices in other countries. Meier's study[1] of science in the German schools revealed the undeveloped state of elementary science in our schools as compared with those of Germany. Her study also indicated a much more thorough preparation on the part of German elementary-school teachers.

It is only recently in this country that elementary-school teachers generally have been required to prepare for science teaching. No adequate surveys of the training of elementary teachers in science have appeared. Brechbill[2] studied the courses in the teaching of science offered in a number of the larger colleges and universities. He found that 78 per cent offer courses in this field. Three-fourths of the courses were devoted to the teaching of sciences in the secondary school, one-fourth to the teaching of science in general. There is no indication in the report of his study as to the attention given to teaching elementary science in these general courses. A number of institutions have recently organized courses in the teaching of elementary science.

Needed Studies

We cannot always foresee the contributions of research. Some pure research undertaken without any reference to its application in improving science teaching may open new professional vistas and lead the way. In all matters in which we are able to visualize definite needs, much research effort ought to be directed toward these ends.

One of the most basic of these needs is the measurement of functional outcomes of science teaching. The recording of factual knowledge on the examination paper has afforded very little evidence as to whether science teaching is functioning in important ways in the child's life. The measurement of functional outcomes is not an easy research problem. It is not a simple matter to discover what new avenues of interest and satisfaction

[1] MEIER, LOIS, "Natural Science Education in the German Elementary Schools," Contributions to Education No. 445, New York: Teachers College, Columbia University, 1930.

[2] BRECHBILL, HENRY, Status of College and University Offerings in Teaching of Science, *Science Education*, 18: 221–225, December, 1934.

the child is following, what growth has taken place in social attitudes and appreciations, what evolution his concepts of life and environment have undergone, and whether or not he manifests scientific attitudes and utilizes scientific knowledge in meeting his problems. But the measurement of these functional outcomes with a fair degree of accuracy is so basic to progress in science teaching as to deserve the best efforts of our most competent researchers.

Once we are able to measure functional outcomes, the way will be opened for significant comparative studies of methods, plans of organization, and other problems of instruction. So long as we continue to measure largely factual learnings while the more progressive teachers are emphasizing more vital functional outcomes, the contribution of research along these lines will be limited. It is important to note, however, that we shall always be interested in the measurement of factual learnings not as ends in themselves but as part of the essential equipment for intelligent functioning.

We also need to know more about what children at the various age levels are able to accomplish. At what stage in the child's development can we reasonably hope to open to him the various new avenues of interest and satisfaction attainable through our science program? When can he generalize, and to what extent? How early is he able to comprehend and utilize the various facts, principles, and skills important in maintaining existence? We know that some of these are relatively simple of understanding and application, while others are highly complex and difficult to comprehend, but we lack experimental evidence upon which to judge the difficulty of each for the child. We know, perhaps, even less about the possibilities of developing social attitudes and appreciations at the different grade levels. This is equally true of scientific attitudes and procedures. We need many careful studies of what groups of children can readily accomplish. Moreover, we need measures of the range of individual differences in these abilities which we may expect in an ordinary grade-group.

The measurement of functional outcomes of science teaching and of the capacities of children at the various levels of learning are important types of research, but there is a third task no less urgent. We must study the lives of children today with their personal and social problems to discover what children need to

achieve. There are so many things that we could do in our science work, and the time is so inadequate that it is evidently impossible to do all of them. They may be within the range of the capacities of the children in our room, and evidence may be available to show that they can be made functional, but are they the most worth while in the light of the needs of the child? When a child begins to go about alone or to purchase the articles that he uses, new educational needs arise. When he learns to ride a bicycle or to drive an automobile, a great obligation is thrust upon every educational agency. No adequate analysis of childhood needs is available which might serve even as a pattern for the teacher in studying the needs of her own pupils. The analysis should not be limited to matters concerned with personal needs. The child's acts have social consequences. As he widens his range and sphere of activities, new needs in the way of social attitudes and appreciations arise. As he begins to wonder about things and to try to explain them in terms of limited and inadequate concepts, newer and broader concepts are needed. Likewise, the avenues of interest and satisfaction change with age. To study these changing needs that we may better meet them is to direct the forces of research in a frontal attack on one of the most basic problems of education.

Paralleling these lines of study we need further studies in method. As pointed out earlier in this chapter in the review of research contributions, few method studies have appeared in the elementary science field. Comparative studies of method in the future must take into consideration other outcomes as well as factual learnings, if the results are to be convincing to the large and growing group of progressive teachers.

Another needed contribution, which while it may not be classed as basic research is nevertheless important, is the finding and compiling of teaching helps. We need enriched science syllabi, suggestive rather than prescriptive. There is also need of compilations of the best units, projects, procedures and techniques, sources of materials, and references that have been developed in the various teaching centers and school systems throughout the country. There is a dearth of suitable supplementary reading material in elementary science offering abundant opportunity for the creative efforts of many workers.

With all of these needs to be met, there is no lack of opportunity for research and other creative work in the rapidly developing

field of elementary science education. Rather, the question is: Where can we hope to find capable workers for so large a task? Heavy teaching loads limit the time that most educators can devote to research. Certainly, some of the most capable investigators ought to be freed in part from teaching duties for research, the influence of which will extend farther than direct instructional efforts. More productive efforts may be expected from graduate-school science education centers. The National Association for Research in Science Teaching, although of limited membership, is a stimulus. The American Science Teachers' Association and federated organizations, the Department of Science Instruction of the National Education Association, the National Council on Elementary Science, and other similar organizations do much to foster research. The publication of research bibliographies[1] tends to coordinate and stimulate research efforts. Teachers colleges are beginning to be production agencies as well as training centers. Supervisors and teachers of elementary science in increasing numbers are adopting a research attitude, with the result that important contributions to the literature and science of the field from public school systems are appearing. As more highly trained teachers take their places in the elementary field, this source of contributions ought to increase rapidly. The research attitude is developing, but the products of research represent a gradual accumulation and evolution out of the achievements and contributions of innumerable creative individuals and groups.

[1] For example, see the following:

PIEPER, CHARLES J., Research Studies Relating to the Teaching of Science, *Science Education*, 17: 138–150, April, 1933; 18: 112–116, April, 1934. ROBERTSON, MARTIN L., A Review and Evaluation of the Curricular Studies Pertaining to Elementary Science, *Science Education*, 18: 86–93, April, 1934.

PART II

SUGGESTIONS FOR AN ACTIVITY PROGRAM

AN ACTIVITY SOURCEBOOK

FOREWORD

The analysis of activities which constitutes the major portion of the book is intended as source material for the busy teacher. Most of the activities have been carried out in a number of schools. The material has appeared in mimeographed form and has undergone two revisions on the basis of the experiences and suggestions of many teachers. To all of these—too numerous to credit separately—the author wishes to express his appreciation.

Some of the activities described in these pages can be carried out successfully only at certain seasons of the year. Those which need to be started very early in any season are so arranged in this book, while experiences that may with equal or better success be deferred until late in the season are placed near the end of the list. Otherwise, activities concerned with similar phases of the environment are grouped. Where some of these are more advanced or depend upon other experiences, as in the case of those dealing with magnetism and electricity, the arrangement approximates a sequence. Activities that should be continued throughout the year are included in the list for fall and reappear in some form in the winter and spring outlines.

For various reasons, grade placement has not been indicated for most of the activities. Objective evidence on which to base grade placement in elementary science is very meager. So little has been done in elementary science in many schools that it is not safe for the teacher to assume that her pupils have a background of experience from the work in the preceding grades. Many activities can be adapted to various grade levels. The level of ability and maturity varies considerably within a grade group, as does the average level of ability of the pupils in any grade from year to year. In rural schools and in many village schools where the teacher is in charge of more than one grade, it is often advisable to combine classes in elementary science. The grade placement of subject matter and activities varies rather markedly in even the better published courses of study. Lastly, the rigid prescription of grade placement of learnings does not fit well into the ideas and practices in some of the most progressive schools.

These facts do not prevent the eventual determination of simpler and advanced activity approaches toward the accomplishment of our aims. However, were definite grade placements indicated in this analysis of activities, they might deter some teachers from adapting the suggested procedures to their own science programs.

With the exception of a few suggestions here and there, arousing interest in undertaking the activity has been left to the teacher's ingenuity and general teaching skill. Many teachers are highly skilled in this ability and do not feel the need of help along this line so urgently as they do the want of information and of ways and means of going about the undertaking. Few elementary teachers feel that they have the necessary knowledge of science and of scientific method to make a program of science activities effective, though they may be good directors of activity in other fields. For this reason, most of the available space in these pages has been devoted to analyses of outcomes, suggestions for procedure, and statements of contributing learnings. While the learnings are couched in simple statements, their formulation within the vocabulary range and language ability of the children is left to the pupils and teacher in each grade. Certain contributing learnings important in achieving the aims may not result directly from the execution of the activity. However, in such cases, the activity provides an excellent experience basis for comprehending the additional learnings. In the section headed "Suggestions," suitable procedures for pupils to employ are briefly described. They are not intended as directions to be given to the pupils but rather as an aid to the teacher in her conferences with them. A good director of activity lets a child find his own way and provides only such help as he needs.

A number of selected references for carrying on the activities are included. References that are not beyond the level of reading ability of elementary pupils or that contain valuable illustrations are starred. Citations to songs, poems, games, and other emotional accompaniments of the activity program have been omitted. The teacher will find many references of this nature in courses of study. No references to fugitive sources have been given, although much valuable material of this nature exists.

While health and safety are of the greatest importance in science teaching, the analysis of activities to accomplish this aim became so voluminous that it proved necessary to publish it

separately. Accordingly, only a few activities primarily concerned with health and safety are included here.

The activities described in this book are only a few of the many suitable ones that may be carried on in the elementary science program. The aim has been to include activities involving a wide range of experiences, better to enable the teacher to carry on in many lines of endeavor and to devise new undertakings. It is the common experience of all teachers who teach largely by this method that it requires a great deal of effort to direct an activity for the first time. One of the main purposes of this analysis of activities is to reduce this load as much as possible. Succeeding experiences in directing any activity will prove much easier and even more enjoyable, especially if the teacher will keep a good record of the sources of material, devices, references, and everything else that proved useful.

Lest the reader who has opened the book to this second part be lured to direct these undertakings as mere stunts, or as activity for the sake of activity, urgent request is hereby made that she read the earlier chapters of the book and the general literature of the field before attempting to use the source material. Unless she has formulated a guiding philosophy, and especially until she has a clear vision of the goals of her efforts, these suggestions for an activity program in science will be instruments of little value to her in helping children achieve the aims of education.

AUTUMN SCIENCE ACTIVITIES FOR THE ELEMENTARY SCHOOL

EXPLORING THE SCHOOL GROUND

Aims

Interest in school life and enjoyment of the new surroundings.
Joy in exploration and discovery.

Suggestions

These explorations should be made the first days of school. Let the children play that they are Byrd, Lindbergh, and other explorers. Welcome each discovery, and call attention to interesting facts about it. Lead the children to discuss each discovery, telling what they have learned by observation and experience concerning it. Utilize some of the interests thus developed as points of departure for further studies of the lives of the plants and animals, the best use of school facilities, safety, etc.

Tidy the school ground, and remove any hazards discovered such as broken glass and nails. Discuss ways of having a good time at school. Plan places to play various games without disturbing plant and animal friends more than necessary.

The city school usually employs more mechanical equipment, while the country school may afford a richer plant and animal life. But either school, regardless of how barren it may seem, offers opportunity for exploration in both the living and nonliving phases of the environment and can be made interesting to the children.

Contributing Learnings

The aim in this introductory activity is largely adjustment, but it is possible to develop interesting information concerning all of the discoveries. These may include such things as entrances, walks and paths, playgrounds suitable for various games, play apparatus, shrubs, trees, weeds, wild flowers, cultivated flowers and grass plots to be protected, birds, birds' nests, insects (in various stages, anthills, galls, cocoons, etc.), water hydrants, power wires, telephone wires, fire extinguisher, water supply, broken glass and other hazards, toilets, lavatories, heating

plant, fuel supplies, library, school supplies, and pictures. The objects to be discovered will vary so greatly with the location and nature of the school that it is scarcely feasible to list here the facts and principles to be learned. In general, they will deal with the equipment and, in a very elementary way, the processes that have contributed to it, the operation and use of the facilities provided, interesting facts about the plants and animals, and ways of living together happily in the new school environment.

ESTABLISHING A NATURE TRAIL

Aims

Greater ability to find interests in the immediate outdoor environment.

Basic experience contributing to understanding of the environment and the interrelations of living things.

Suggestions

Nature trails are usually established for the benefit of others, but the act of establishing the trail can be very educational. The children will be eager about it if the idea is explained to them.

An interesting trail may be established anywhere, even on the barest-appearing schoolground, but the most interesting spot convenient to the school should be used. If there is a park near the city school, permission can easily be obtained from the park superintendent to put up a few markers.

Go over the ground as a group to select the points of interest to be marked. These may consist of ant colonies, insect galls, insect damage to various parts of plants, birds' nests, other animal homes, tracks, rocks, evidences of erosion, soil types, leaf mold, interesting trees, shrubs, wild flowers, bad weeds, fungi and other parasites, fruits, competition, evidence of fires, interesting views, effects of wind, drought, floods, snow, ice, and hail, interesting coloration, effects of shade and sun, works of man and examples of his ruthless destruction, or any of a legion of other things in nature worthy of observation. Before laying out the trail, let the children look up all the information available to them concerning each of the interesting things observed and discuss each point of interest. The observations will then take on new fascination, and the group will be ready to lay out the trail.

Several common methods are used in marking nature trails. Small markers are usually placed near or on the points of interest. The markers may carry brief statements in the nature of explanations of the interesting features to be observed or challenging questions to direct the observation. Some trail makers prefer to place only a number on the marker and to prepare an explanatory

sheet correspondingly numbered to accompany it. Others place no markers on the trail but give directions in the explanatory sheet how to proceed to each point of interest, leaving to the traveler the experience of discovering the features explained.

Encourage pupils in other grades, parents, and visitors to travel the trail. The markers and sheets may be changed from time to time, as the season progresses and new interesting events in the cycle of nature occur.

Contributing Learnings

(It is not possible to state the contributing learnings here, as they will vary with the location of the nature trail and the selection of items of interest. The accomplishment of the aims depends in large measure on the development of rich meanings.)

References

Cornell Rural School Leaflet, Vol. 23, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1929.

LUTZ, FRANK E.: "Nature Trails," Miscellaneous Publication, No. 21, The American Museum of Natural History, New York: American Museum Press, 1931, 38 pp.

MANN, PAUL B., and GEORGE T. HASTINGS: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 346–360.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book I: "Hunting," New York: The Macmillan Company, 1932, 161 pp.

EXHIBITING SUMMER PROJECTS AT THE SCHOOL FAIR

Aims

Stimulus to creative activity.

Interest in the summer season and enjoyment of leisure hours.

Suggestions

Plans for the school fair should have been made in the spring before the summer vacation. The fair is held for all grades as soon as possible after the opening of school. Products of the children's creative efforts during the summer of every type should be displayed.

Science activities will likely be represented by such achievements as:

Flowers and vegetables grown by the children.

Collections of insects, leaves, wood samples, fruits, shells, stones, pictures, and other interesting things.

Interesting records, curios, and other materials secured during summer travels.

Simple models and devices constructed by the children.

Insects and other animals reared by the children.

Aquariums and terrariums.

Records of observations of birds and other animals.

Booklets, weather records, nature calendars, and diaries of the summer season.

Prizes are unnecessary. It is well to spend some time talking over the exhibits. Give the children an opportunity to tell of their experiences and to explain their exhibits.

Contributing Learnings

(On account of the immense range of possible undertakings it is not feasible to list the informational outcomes here. The teacher should analyze the activities represented in the exhibit to determine their informational contributions.)

References

MEISTER, MORRIS: "Children's Science Fair of the American Institute: A Project in Science Education," New York: The American Museum of Natural History, 1932, 48 pp.

KEEPING A NATURE CALENDAR

Aims

Consciousness of seasonal changes and greatly increased interest in the natural environment.

Experience contributing to the concept that climate is the great control of life to which all forms including man must adapt themselves.

Suggestions

Signs of fall have begun to appear by the first of September.

Observe changes in the length of day, position of the sun, temperature, and precipitation.

There are many opportunities for observation of changes in plants as the different species change color, drop leaves, ripen fruits, become dormant, or die.

Record the behavior of some of the commoner animals, as squirrels and other rodents storing food, birds and monarch butterflies migrating, insects crawling into buildings to hibernate, and the disappearance of species that have been common during the summer. Note the changes in human activities.

Listen for familiar sounds, and record the changes as fall advances into winter.

To simplify the recording, the calendar may be arranged by weeks, rather than days. Various forms of calendar records can be kept, using actual objects, pictures, drawings, and written records. A large calendar is advisable. A blackboard calendar or one made on a large cardboard is satisfactory. This enterprise offers a splendid opportunity in art and language as well as in science.

Contributing Learnings

The material in the leaves, which made our surroundings green in summer and is so important in making food, disappears and is replaced by yellows, browns, and reds.

Leaves fall from broad-leaved trees. The dead brown leaves remain on some white oaks, red oaks, and occasionally other trees.

The needle-leaved trees—pines, spruces, firs, etc.—drop some of their leaves in the fall but retain most of them. Hence, they are always green.

Many plants are dead by fall (annuals); only the new baby plants in the seeds are now alive. Some plants die back aboveground but live over below ground, where they are somewhat protected.

Many plants have ripened their fruits and seeds during the summer. The others are ripening rapidly and will have a crop of seeds to start next year's plants. Fall brings seed time and harvest. Many of the fruits as well as the seeds are good to eat. We and some of the other animals put large quantities of them away for food, keeping some of the seeds to plant.

There are fewer hot days now; the air is cool and bracing in the morning and evening. Fires are built. Heavier and heavier frosts kill the tenderest plants such as cucumbers, nasturtiums, coleus, and, finally, all except those which, like bluegrass and dandelions, remain wintergreen.

Days grow shorter; the nights, longer.

The various migrant birds pass through on their way south. Gradually the summer residents depart, and only the permanent residents and a few winter birds are left.

Insects, which have been multiplying throughout the spring and summer, are very abundant in early September. They soon begin to disappear rapidly. Some, like the grasshoppers, die. Many go into the soil. Others throng our screens and crawl into every conceivable cranny which can afford winter protection.

Snakes go into their holes in the ground late in fall. Frogs go to the bottoms of ponds, lakes, and streams. Squirrels are busy storing nuts in their winter homes and later are seen only occasionally. Most of the other fur-bearing animals continue more or less active, while some go into their dens to sleep until warm weather comes again.

References

*Beauchamp, Wilbur L., Gertrude Crampton and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 14–21.

Beebe, Charles William: "The Log of the Sun, A Chronicle of Nature's Year," Garden City, New York: Garden City Publishing Company, 1906, 321 pp.

*Carr, William H.: "The Stir of Nature," New York: Oxford University Press, 1930, pp. 32–35.

**Cornell Rural School Leaflet*, Vol. 23, No. 2: Through the Year, Ithaca, New York: Cornell University, November, 1929.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn & Company, 1932, pp. 5–15.

GIBSON, WILLIAM HAMILTON: "Sharp Eyes—A Rambler's Calendar of Fifty-two Weeks among Insects, Birds, and Flowers," New York: Harper & Brothers, 1897, pp. 176–243.

*GORDON, EVA L., and JENNIE HALL: "Nature Stories for Children—An Autumn Book," New York: Mentzer, Bush & Company, 1926, 87 pp.

HOWES, PAUL GRISWOLD: "Backyard Exploration," Garden City, New York: Doubleday, Doran & Company, Inc., 1927, pp. 24–26.

*HYLANDER, CLARENCE J.: "The Year Round," New York: G. P. Putnam's Sons, 1932, pp. 173–212.

JOHNSON, GAYLORD: "Nature's Program," Garden City, New York: Doubleday, Doran & Company, Inc., 1926, pp. 123–150.

*METZGER, OLIVER P.: "Nature Rambles—Autumn," New York: Frederic Warne & Co., 1932, 160 pp.

PACK, ARTHUR NEWTON, and E. LAURENCE PALMER: "The Nature Almanac—A Handbook of Nature Education," Washington, D. C.: The American Nature Association, 1927, pp. 20–27.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 1–52.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1932, pp. 1–78.

SHARP, DALLAS LORE: "The Fall of the Year," Boston: Houghton, Mifflin Company, 1911, 126 pp.

KEEPING A DIARY OF FALL VISITS TO A FAVORITE TREE

Aims

Interest in seasonal changes. Interest in trees that leads to appreciation.

Experience contributing to an elementary concept of life processes.

Suggestions

It is an excellent plan to observe the same tree throughout the year. Let the children select a class tree or a tree for each group.

The first visit to the tree should be made as early as possible while the tree is in summer condition. Visit the tree every week or two and as soon as possible after violent winds, frost, hail, excessive heat, or other extreme conditions.

Note the general shape, comparing with elm, spruce, lombardy poplar, and weeping willow. Get a photograph of the tree in summer and fall conditions.

Stand close to the trunk and discover where the leaves are located on the tree. Compare the two sides of a leaf. Explain that leaves make the food used for growth of fruits and seeds and of man and other animals. To get a conception of the immense leaf surface, collect a large pile of fallen leaves, and spread them out on the ground fitted together like quilt blocks. Collect green and colored leaves, and mount them with the tree photograph.

Try to decide what the trunk and branches do. Notice what happens to the bark on the older parts of the tree.

Observe the large roots at the base of the tree, and look for evidences of roots farther away. Think about their uses. Discover the effect of the tree on the grass and other plants.

Note that there is a bud by each leaf. Further study of buds can be made better in winter.

If the tree has fall fruits, collect them in as many stages as possible, for the tree mount. Find the baby plant in the seed, the stored food, and the protecting seed coats.

Make observations of insect, bird, and mammal visitors to the tree; injuries; healing; decay; algae, lichens, and mosses on the bark.

After getting a general acquaintance with the tree, at each succeeding visit note especially the changes that have occurred.

Contributing Learnings

The tree carries an immense area of leaves which make food. The leaves are near the outside of the tree where they get sunlight. Some trees spread their leaves in a broad or rounded top, while others expose them in a long cone. The branches extend in various directions and spread the leaves out to the light.

The trunk holds the leafy branches up to the light and carries water and food up and down. The bark protects the tree from drying out and from injury and decay, as does our skin. As the branches and trunk grow too large for their bark covering, it cracks and becomes ridged, new bark forming inside the old.

Having tried to hold an umbrella on a windy day, we can realize how strong the roots must be to hold a large tree erect. We water the soil around our plants so that the roots can take up the moisture. A large tree takes up as much as a barrel of water during a hot summer day. The tree roots and the dense shade sometimes keep the grass from growing well under the tree.

The buds which will make next year's twigs, leaves, and flowers are already formed. During the fall the leaf-green disappears; the leaves turn yellow, red, and brown and cease to make food.

We do not know what causes the leaves to fall. They sometimes fall before frosts and often not until afterward. Therefore, the frost does not cause them to fall, as many people think.

There are many kinds of fruits, some fleshy, some dry. Birds, squirrels, and many other animals like the fruits and the seeds that they contain. We also eat fruits and seeds. Each seed contains a baby plant which may grow into another tree. Most of the seed is stored food. The seed coats protect the baby plant and its supply of food until it can grow. The seeds and fruits are scattered about in various ways.

Trees are the homes of squirrels, birds, insects, and some other animals. Many others visit trees for food and protection. Almost all of the leaves are partly eaten by insects. Trees have many injuries and accidents.

Mosses and other small green plants (algae, lichens) grow on the north sides of many trees where they are somewhat protected from the hot drying sun. Shade-loving plants grow beneath the trees.

Trees change with the season, and there are always new and interesting things to discover about them.

References

*Athey, Lillian Cox: "Along Nature's Trails," New York: American Book Company, 1936, pp. 203–234.

Comstock, Anna Botsford: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 726–816.

*Curtis, Mary I.: "Stories in Trees," New York: Lyons and Carnahan, 1925, 224 pp.

*Dorrance, John Gordon: "The Story of the Forest," New York: American Book Company, 1916, 237 pp.

Emerson, Arthur I., and Clarence Weed: "Our Trees and How to Know Them," Philadelphia: J. B. Lippincott Company, 1908, 295 pp.

*Gehrs, John H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 137–161.

Hawksworth, Hallam: "A Year in the Wonderland of Trees," New York: Charles Scribner's Sons, 1926, pp. 1–56.

Mann, Paul B., and George T. Hastings: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 193–214.

Moseley, Edwin Lincoln: "Trees, Stars, and Birds," Yonkers-on-Hudson, New York: World Book Company, 1922, pp. 1–156.

Pack, Charles Lathrop, and Tom Gill: "Forest Facts for Schools," New York: The Macmillan Company, 1932, pp. 5–40.

*Patch, Edith M.: "First Lesson in Nature Study," New York: The Macmillan Company, 1932, pp. 251–261.

*——— and Harrison E. Howe: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 39–42.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 1–10, 61–67.

*Persing, Ellis C., and Elizabeth K. Peeples: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 54–59.

Rogers, Julia Ellen: "The Tree Book," Garden City, New York: Doubleday, Doran & Company, Inc., 1922, 589 pp.

REARING INSECT LARVAE

Aims

Interest in the wonders of insect life. Interest in seasonal changes.

Development of attitudes which exclude fear and repugnance of crawling things.

Experience contributing to understanding of reproduction and development.

Suggestions

Larvae of some insects can be collected early in September, and there is the advantage that they will usually pupate within a few days. Eggs may also be collected and hatched.

Any larvae the children collect will do. It is well to look for some of the following, and in the course of the search many others will be discovered.

Fall webworm.—On apple, box elder, ash, and other trees. (Take the branch, web and all.)

Cabbage butterfly larvae.—On cabbage and cauliflower.

Swallowtail butterfly larvae.—On celery, dill, parsley, and parsnip.

Corn earworm.—Inside the husks of late sweet corn.

Sphinx moth larvae.—On willow, virginia creeper, grape, tomato.

Yellow Bear and Salt-marsh caterpillars.—On plantain, most garden crops, grasses.

Tussock moth larvae.—On shade trees.

Painted Lady or Thistle butterfly larvae.—On thistle and hollyhock.

Fly maggots.—In manure and garbage.

Colorado Potato beetle larvae.—On potato and tomato.

May beetle larvae.—In soil about the roots of plants.

Lady-bird beetle larvae.—On garden plants.

Bring in leafy twigs of the plants on which the larvae are found. Stand the twigs in a bottle of water, and plug the neck of the bottle with cotton to prevent the larvae from drowning. Then transfer the larvae as gently as possible to the leaves. Move them to fresh twigs when the leaves are eaten or show signs of wilting.

Some larvae pupate in soil, so it is well to sink the vessel containing the twigs in a box or flowerpot of moist (not wet) soil. A lantern globe or insect cage is not essential, although some larvae have a tendency to roam. If the bottles are placed in battery jars or aquariums, flypaper may be glued, with the sticky surface exposed, to the upper inner margins of these containers to prevent the larvae from crawling out.

If the food plants dry out before the larvae have time to eat the leaves, cover the containers.

Observe how the larva eats. Note the quantity of food consumed in one day.

Learn to distinguish larvae from worms by comparing with earthworms.

Watch for molting as the larvae grow. Observe the formation of the pupa case and the spinning of the cocoon by some of the moth larvae.

Place the pupae in a cool, moist place over winter to enjoy the emergence of the adults in the spring. A much higher percentage of success will likely be achieved with these pupae formed indoors than with those collected out-of-doors since the latter are frequently parasitized.

Contributing Learnings

The young of these insects do not resemble the adult. (Children will learn later of other insects whose young are nymphs.) Instead, they somewhat resemble worms. The larvae usually have six true legs. Worms are legless.

Larvae eat great quantities of food. They spend practically all of their time eating. Their jaws work sidewise instead of up and down as ours do.

They grow very rapidly and soon get too large for their outer covering. Then the covering splits, and the larva crawls out. It secretes a liquid which hardens into a new protective covering. There are commonly as many as five of these larval molts. This covering is the larva's only skeleton, since there are no bones within its soft body.

When full grown, the larva forms a cell or pupa case in which it transforms to an adult. Larvae of some kinds of moths spin cocoons of silk in which they pupate.

Insects do not take food or move much in the pupa stage, although they twist about when disturbed. Although they seem

inactive, this is a busy stage, as great changes must take place to make a butterfly, moth, fly, or beetle of a wormlike larva. Some larvae go into the ground to pupate. Most larvae seek places that are not too wet when they are ready to pupate.

Many insects spend the winter in the pupa stage.

References

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 308–457.

**Cornell Rural School Leaflet*, Vol. 19, No. 4: Moths and Butterflies, Ithaca, New York: Cornell University, March, 1926.

*CRAIG, GERALD S., and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 329–339.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 117–132, 179–205.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 35–46.

ELIOT, IDA MITCHELL, and CAROLINE GRAY SOULE: "Caterpillars and Their Moths," New York: D. Appleton-Century Company, Inc., 1902, 302 pp.

HOWARD, LELAND O.: "The Insect Book," Garden City, N. Y.: Doubleday, Doran & Company, Inc., 1905, pp. 396–400.

*JOHNS, LENA M., and MAY AVERILL: "Moths and Butterflies," Dansville, N. Y.: F. A. Owens Publishing Company, 1930, 127 pp.

LUTZ, FRANK EUGENE: "Fieldbook of Insects," New York: G. P. Putnam's Sons, 1921, 510 pp.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book VI, New York: Silver, Burdett & Company, 1935, pp. 21–46.

*PATCH, EDITH M.: "Hexapod Stories," Boston: Little, Brown & Company, 1920, 168 pp.

*PAYNE, E. GEORGE, HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book I, Boston: Benjamin H. Sanborn & Company, 1927, pp. 79–89.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 22–26.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 18–24.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 19–25.

*PHILLIPS, MARY GEISLER and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book II: "Some Animal Neighbors," Boston: D. C. Heath & Company, 1936, pp. 4–121.

*——— and ———: "Nature—By Seaside and Wayside," Book III:

"Plants and Animals," Boston: D. C. Heath & Company, 1936, pp. 68–123.

SCHMUCKER, SAMUEL CHRISTIAN: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 89–135.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book II, Philadelphia: J. B. Lippincott Company, 1931, pp. 143–153.

*——— and ———: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company, 1931, pp. 120–125, 131–135, 141–148.

WEED, CLARENCE M.: "Butterflies Worth Knowing," Garden City, New York: Doubleday, Doran & Company, Inc., 1923, 286 pp.

———: "Nature Biographies," Garden City, New York: Doubleday, Doran & Company, Inc., 1901, 164 pp.

ARRANGING AN INSECT ORCHESTRA

Aims

Awareness and greater enjoyment of insect sounds and interest in insect ways.

A degree of realization of the unchanging instinctive behavior of insects and especially of the driving force of the reproductive instinct.

Suggestions

It is necessary to begin soon after the opening of school in the fall. A screened cage over a box of dirt makes the best "orchestra pit," but several lamp chimneys over flowerpots filled with earth will do. A screened cage can easily be constructed by making a yard and a half of screen-wire cloth into a roll, sewing or stapling the lap, sewing in a cloth top to close the upper end of the roll, and standing it in a candy bucket filled with earth.

Dig up a clump of grass with a ball of earth about the roots, and transplant to the insect chamber. If a large box is used, it is well to transplant other plants and to keep a few tree twigs in a small-necked vessel sunk in the soil. Put a little honey in the cage to feed the bees and flies. Most of the other insects will feed on the grasses. Keep the soil moist.

Collect as many species of crickets as you can find about buildings, under objects, on rock exposures, and in the fields. Look on raspberries and in trees for the tree crickets.

Catch a number of kinds of locusts and grasshoppers in the meadows and fields. Get a few katydids.

Locate cicadas during the heat of the day by their high, shrill, continuous loud sounds. Look about under the trees for them again toward evening.

Bring in honeybees, bumblebees, and any other species of bees and wasps you may find. They can be taken safely from flowers by holding a jar to the flower and quickly pushing the insect into it with the lid as you close it.

Collect a number of species of flies and some mosquitoes.

Catch a few of the May beetles and pinching beetles around the lights in the evening.

If the children have trouble finding some of the insects that you need, let it be known that you desire certain species, and some one in the community is almost certain to supply them.

The orchestra will not follow the leader, but there will be a series and often an interesting medley of sounds. By observing the insects closely, try to discover how the sounds are made. Find the pitch by sounding a pitch pipe or piano. Find whether each insect makes more than one type of sound.

Move the cage about the room from sun to shade, and note any change in the sounds. Cover the cage to exclude light, and listen.

If any of your insects fail to play their parts in the orchestra, replace them with others, as only the males of some species are capable of making sounds.

Contributing Learnings

As Comstock states, "There is a great orchestra which is performing constantly through the warmer portions of the year, which is almost unnoticed by man." Many insects produce sounds.

The sounds are made in various ways. Crickets and some grasshoppers rub the two front wings together to make their chirping and rasping sounds. The wings bear a comblike file and a scraper. As the wings are moved in certain positions, the file rubs on the scraper, producing the sounds. The Carolina locust rubs the forewing against the hind wing. Many other locusts rub the roughened inner surface of the hind legs against the outer surface of the forewings.

The cicadas have very complicated sound-producing organs covered by a membrane like a drumhead on the underside of the body.

May beetles are said to have buzzing organs near the breathing pores, but we do not know exactly how they manage to buzz so loudly.

Flies, bees, and many other insects make sustained tones by the rapid vibration of their wings. The housefly tone is about F above middle C on the piano, which is produced by more than 20,000 vibrations (not necessarily whole wing movements) per minute.

Insects make sounds in many other ways. The sounds seldom if ever come from their throats. They commonly continue on the same pitch, though some insects can vary this.

Most insects fiddle and drum away alone. In most species only the male can produce the sounds, but in some the sexes call back and forth. All of the tree crickets in any locality chirp together.

Most insect sounds are thought to be calls to attract mates. Much of the adult life of insects is spent in securing mates and rearing young.

Insects of the same species vary little in their singing. They have produced the same sounds without change as long as we have any records of them.

Some insects produce a variety of sounds which probably approach a simple language. The honeybee hums contentedly, buzzes angrily, makes a swarming sound, etc.

Insect sounds are counted among the joys of the summer season by those who listen and understand. The songs of crickets, katydids, and cicadas appear often in poetry.

References

COMSTOCK, ANNA BOTSFORD: "Ways of the Six-footed," Boston: Ginn and Company, 1903, pp. 3–28.

COMSTOCK, JOHN HENRY: "An Introduction to Entomology," Ithaca, New York: Comstock Publishing Company, 1924, pp. 78–93.

Cornell Rural School Leaflet, Vol. 25, No. 2: Fall Insects, Ithaca, New York: Cornell University, November, 1931.

HAWKSWORTH, HALLAM: "The Clever Little People with Six Legs," New York: Charles Scribner's Sons, 1924, pp. 258–279.

*HODSON, GLEN EATON: "Mother and Ann Nature Stories," St. Paul, Minn.: Webb Book Publishing Company, 1928, pp. 149–152.

LUTZ, FRANK EUGENE: "Fieldbook of Insects," New York: G. P. Putnam's Sons, 1921, 510 pp.

*PHILLIPS, MARY GEISLER and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book III: "Plants and Animals," Boston: D. C. Heath & Company, 1936, pp. 75–88.

POWERS, MARGARET: "The World of Insects," Chicago: Follett Publishing Company, 1931, pp. 83–90.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 56–58.

PREPARING AN EXHIBIT SHOWING DAMAGE AND BENEFIT FROM INSECTS

Aims

A more intelligent attitude than is now common toward our greatest competitors and valuable allies, the insects.

Some ability to aid in the solution of insect problems at home.

Some contribution to the concept of the vast amount of interrelationship existing among living things.

Suggestions

This activity commonly has its inception in insect damage occurring in and about the homes and school, or it may be started by bringing in a few samples of insect injury. The types of injury and benefit to be exhibited can be worked out by the children from the pictures and accounts contained in the first two chapters of the book "Destructive and Useful Insects," by Metcalf and Flint.

Let the children collect as many as possible of the following types of injury and benefit, arranging them in an attractive exhibit with explanatory labels. Wherever possible, include the insects responsible for the damage or benefit. Begin with the nonperishable materials, and build the exhibit gradually. Usually, much assistance can be expected from the community.

Some suggestions for the exhibit are:

Insect Damage

Clothing partially eaten by clothes-moth larvae.

Skins, furs, and mounted insects and other animals damaged by small beetles.

Wood largely destroyed by ants and termites.

A short length sawed from the trunk or branch of a dead tree showing engravings of the engraver beetles.

Similar sections of wood showing the work of some of the wood-boring beetles.

Raspberry canes and rhubarb stalks ruined by egg-laying punctures of tree cricket and snout beetle

Plants with all of the small roots chewed off by the white grubs. (Examine dying grasses and young evergreens Almost any nurseryman will gladly furnish examples.)

Plants cut off near the ground by cutworms.

Seeds tunneled by wireworms after planting.

Stem of corn or other plant containing or injured by a stem borer.

Curled leaves containing plant lice or aphids.

Potato, cabbage, cucumber, and other plants with leaves badly eaten by chewing insects.

Leaves of grape, apple, and other plants with many tiny colorless areas resulting from the punctures of leaf hoppers and other piercing-sucking insects.

Leaves showing white streaks and scrolls produced by leaf miners.

Apple and potato leaves with brown tips, the tip burn resulting from a disease carried by the apple-potato leaf hopper.

A wilted cucumber or melon plant, a bacterial disease carried by the striped cucumber beetle.

A blighted branch of pear, a bacterial disease carried by the tiny pear thrips.

Clover heads and other flowers with one side damaged by tiny insects.

"Wormy" apples (usually codlin moth), plums and peaches (a snout beetle, the plum curculio).

An ear of sweet corn damaged and rendered unattractive by the corn earworm moth larvae.

Insect galls on oaks, elms, maples, and many other plants.

A jar of sweets containing ants.

Grain containing weevils and meal worms (larvae of a beetle).

Cereals infested with the little brown confused flour beetle.

Meats containing fly maggots.

Lists of diseases carried by houseflies, mosquitoes, roaches, bedbugs, and other common insect pests.

Insect Benefit

Silk.

A section of honey.

Shellac.

Beeswax.

Cochineal coloring

Many kinds of fruits and some of their pollinators, including bees and syrphid flies.

Wood sections or a list of trees pollinated by insects, including basswood, catalpa, locust, buckeye, wild cherry, etc.

A collection of vegetables, almost all of which are dependent to a large extent upon insects for pollination to produce seeds.

Clover, buckwheat, and other insect-pollinated farm crops together with bumblebees, honeybees, etc.

Shrubs: honeysuckle, spirea, dogwood, flowering currant, lilac, mock orange, etc., which are dependent upon insects for pollination.

Fish in a bowl together with some nymphs of May flies, stone flies, and other water insects which furnish a large part of their food.

A pet fowl or other bird with some grasshoppers.

Parasitized plant lice from a cabbage plant (easily recognized by their glassy appearance).

Parasitized cutworms and tomato worms.

Some rich soil containing remains of insects.

A group of valuable insects which help to control others, including ladybird beetles, tiger beetles, lacewing fly (aphis lion), dragonflies, etc.

A counterirritant, cantharides, made from the bodies of one of the blister beetles (obtainable at the drugstores).

Let the children find from books the best known control measures for the insect pests that are troubling them at home. Add the control measures to the exhibit.

Contributing Learnings

There are about twice as many kinds of insects as of all of the other kinds of animals on earth taken together.

The insects have been on earth much longer than we have and have taken possession of things rather generally. They have become quite varied and have lived in and on almost every kind of living thing. This makes us many problems, for they attack almost everything that we also desire.

We cannot compete with the insects in numbers or in most other respects. We can learn much better than they can, however, and this makes it possible for us to cultivate some of the

beneficial insects and partially to control the hordes of the most harmful ones. But there are too many of them for us to control alone. If it were not for the winter, the heavy rains, the birds, reptiles, toads, frogs, salamanders, fishes, spiders, and the insects that feed upon others, we should be helpless before their attacks and could not live on the earth.

Insects harm us in many ways. They carry diseases to us and to our plants and animals. Insects worry us and annoy our domestic animals until they can scarcely eat or sleep.

Insects destroy our farm crops, gardens, flowers, fruits, shade trees, and forests. They destroy much of our stored food and seeds for planting. They invade our homes and destroy foods, building, furniture, rugs, and clothing.

On the other hand, insects are among our greatest helpers. Without them we should have to do without practically all of our fruits and many of our trees, shrubs, and flowers. We should not have silk to wear, honey to eat, and a number of other useful products. Our soils would not be so fertile as they are, since it is estimated that insect bodies return more matter to the soil than all of the other animals combined. We should also miss the interest and beauty that this abundant and varied group furnishes.

We use many methods of combating insect pests. We plow and spade the ground late in the fall to bury some of them deep and to expose others to the weather, rotate our crops and vary our plantings to escape them, destroy their breeding places, trap them, set their enemies to work on them, infect them with diseases, hand pick them, crush them mechanically, use repellents and fumigants, and poison them with baits, sprays, and dusts. If they chew our plants, we place a stomach poison such as arsenate of lead where they will get it. If they suck juices of plants and animals, we usually spray with a contact poison, such as nicotine sulphate, in such a way as to hit the insects. (For more detailed information regarding control measures, look up the particular insect in such books as Metcalf and Flint, "Destructive and Useful Insects".)

Many people have an unconcerned or disdainful attitude toward insects. As our closest competitors on earth, one of our greatest allies, the most abundant group of living things visible to the eye, and some of the most fascinating of the creatures of nature, the insects merit our interest and challenge our best efforts.

References

***Cornell Rural School Leaflet*, Vol. 18, No. 3: Pests of Plants, Pets, and People, Ithaca, New York: Cornell University, January, 1925.

Cornell Rural School Leaflet, Vol. 25, No. 2: Fall Insects, Ithaca, New York: Cornell University, November, 1931.

*CRAIG, GERALD S., and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 343–375.

*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 43–76.

*HOLLAND, W. J.: "The Moth Book," Garden City, New York: Doubleday, Doran & Company, Inc., 1922, 479 pp.

LUTZ, FRANK EUGENE: "Fieldbook of Insects," New York: G. P. Putnam's Sons, 1921, 510 pp.

METCALF, CLELL LEE, and W. P. FLINT: "Destructive and Useful Insects—Their Habits and Control," New York: McGraw-Hill Book Company, Inc., 1928, pp. 1–68.

NEEDHAM, JAMES G.: "Elementary Lessons on Insects," Springfield, Ill.: Charles C. Thomas, 1928, pp. 140–174.

*PAYNE, E. GEORGE, HENRY R. BARROWS, and LOUIS J. SCHMERBER. "Elementary Science Readers," Book II, Boston: Benjamin H. Sanborn and Company, 1927, pp. 125–130, 201–202.

*PERSING, ELLIS C., and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 13–31.

*——— and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 17–35, 65–77, 291–299, 318–324.

SANDERSON, E. DWIGHT, and LEONARD MARION PEAIRS: "Insect Pests of Farm, Garden, and Orchard," New York: John Wiley & Sons, Inc., 1931, 707 pp.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 59–75.

KEEPING A GALLERY OF BIRD RESIDENTS AND TRAVELERS

Aims

Enjoyment of bird life; appreciation of the wonders of migration.

Experience contributing to the concept that our knowledge is limited.

Suggestions

A few periods in the field soon after school begins will establish a list of some of the birds most abundant in the vicinity of the school. Post the pictures of these birds in a conspicuous place.

The early morning and the late afternoon periods are better than the middle of the day for these trips. If it is possible to arrange any trips out of school hours, the very early morning is the best possible time, with sunset a good second. It is wise to tell children that we hunt birds Indian fashion, making as little noise as possible and listening all the time for sounds that may help to guide us. Avoid making quick movements. More birds can be seen in a short period of quiet observation than by much long noisy excursioning.

Observe and describe the habits of the commoner birds exhibited in the gallery. Read stories about them. Become so familiar with the common sounds of such birds as phoebe, pewee, and dove that children will listen as well as look to discover whether or not the birds have departed.

As the common birds are no longer seen on the trips or by individual pupils, move their pictures to a new gallery of bird friends who have departed for the south. The remaining ones will be largely permanent residents.

Children in the lower grades do not know geography and will not be able to follow the birds on their southward migration, but they will be interested in what the birds will find in the south, the things that they will do there, and how long they will be gone.

Contributing Learnings

Most birds are active in the early morning. They sing, call to each other, and flit about in search of food.

If we remain quiet or move leisurely, birds show less fear of us, and we are able to observe and enjoy them.

By fall the young birds are all grown and able to make long flights. During the late fall many of the birds begin to leave for the south. Many kinds gather in flocks at this time. We do not know why they go southward. Many people think that it is because food becomes harder to get in the north.

Some kinds, such as robins and blackbirds, stop to feed and rest as they slowly work their way southward. Others, such as plovers and wild geese, make wonderful long flights like an airplane, directly to their new homes in the south.

In the far south, where the warmer weather makes growth possible, our bird travelers will find plenty of food while we are having winter here.

By marking the birds with light metal bands placed around the leg before they leave us, we are finding out where they spend the winter and how many of them return to us in the spring. We should report to the teacher any banded birds that we find. She will send the record to the U. S. Biological Survey. There are many records of birds' returning year after year to the same spot after journeys of hundreds of miles. We do not know how they find their way on these long journeys.

All birds do not go southward in the fall. We still have our winter birds to enjoy. When the snow comes and the trees are bare, we shall be interested in observing how these hardy fellows get along.

The following lists show the approximate date of departure of some of the birds likely to be observed by the children. The data are for the New England and north-central states, and allowance must be made for more southerly localities. There is also some seasonal variation.

Birds leaving the northern states or those gone by the time that school starts early in September: Baltimore oriole, meadow lark, kingbird, cowbird, black tern.

Birds gone from the northern states by the end of September: bank swallow, yellow warbler, whippoorwill.

Birds leaving the northern states during late September and early October: pewee, purple martin, brown creeper, house wren, catbird, brown thrasher, chimney swift, hummingbird, bobolink, scarlet tanager.

Birds gone from the northern states by the end of October: kinglets, dove, phoebe, myrtle warbler, chipping sparrow.

Birds leaving the northern states during late October and early November: ducks (principal flight), robin, bluebird, rose-breasted grosbeak, kingfisher, redheaded woodpecker, flicker, prairie horned lark, most of the hawks.

Birds gone from the northern states by late November: loon, great blue heron, Canadian goose, American bittern, cormorant, killdeer, grackle, song sparrow, red-winged blackbird.

Birds leaving the northern states during December: herring gull.

Permanent residents: nuthatch, blue jay, chickadee, pigeon, quail, partridge, pheasant, prairie chicken, and others according to locality.

References

*Athey, Lillian Cox: "Along Nature's Trails," New York: American Book Company, 1936, pp. 103–158.

*Boulton, Rudyerd: "Traveling with the Birds," New York: M. A. Donohue & Company, 1933, 64 pp.

*Chapman, Frank M.: "The Travels of Birds," New York: D. Appleton-Century Company, Inc., 1916, 158 pp.

———: "Bird Life," New York: D. Appleton-Century Company, Inc., 1931, pp. 48–61.

**Cornell Rural School Leaflet*, Vol. 22, No. 4: A Travelog of Birds, Ithaca, New York: Cornell University, March, 1929.

*Craig, Gerald S., and Margaret G. Condry: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 17–43.

*Eaton, Elon Howard: "Birds of New York," Memoir 12, New York State Museum, Albany, N. Y.: University of the State of New York, 1910, 2 vols.; also separate color plates.

*Mathews, F. Schuyler: "The Book of Birds for Young People," New York: G. P. Putnam's Sons, 1921, pp. 239–316.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 27–38.

*Persing, Ellis C., and John A. Hollinger: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 7–16.

*Roberts, Thomas S.: "Birds of Minnesota," Minneapolis: University of Minnesota Press, 1932, 2 vols.

*———: "Birds Portraits in Color," Minneapolis: University of Minnesota Press, 1934, 201 pp.

*———: "295 American Birds" (color plates only), Minneapolis: University of Minnesota Press, 1936.

*Trafton, Gilbert H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 282–287.

MAKING FRIENDS WITH THE BIRDS

Aims

Interest in bird life and enjoyment which lead to conservation.

Suggestions

Find out how close you can get to such birds as robins, doves, pigeons, wrens, chickadees, nuthatches, and woodpeckers.

Try various sounds as well as slow and rapid movements to discover what frightens birds most. Note the nervous movements of birds and their disturbed sounds.

Select an undisturbed place on or near the school ground, and distribute a variety of foods at a regular time each day when the playgrounds are not in use. Scatter some of the food on the ground, and fasten meat scraps under the bark or on the low branches of the trees. Watch from a distance to see what birds come. Do not be discouraged if they are slow to discover it at first.

After birds become numerous at the feeding place, give them a few days to become accustomed to feeding there. Then begin to remain closer to the feeding ground after distributing the food. Eventually you can scatter the food and remain perfectly quiet at the feeding place as the birds come and go about you. When they have become accustomed to you and learned that you will not harm them, they will perch on your shoulders, arm, or hand if food is placed there.

Learn the true story of Jack Miner and the birds.

Contributing Learnings

Birds have many enemies and must be on the alert against other animals which may spring or swoop down upon them. They are frightened by sounds and quick movements which may mean danger. They seldom remain long in one spot on the ground and seem to be ever on the alert. They behave in various ways as we approach, moving about nervously, retreating, and making disturbed sounds. When one flies, all seem to understand the signal and follow. Some flocks seem to have lookouts posted to give warning of any approaching danger.

Birds have come to fear us, but it is not difficult to make friends with them. It takes them some time to learn that we will not harm them. After that they show very little fear of us. We get the greatest joy out of birds when they come to accept us in this way.

References

ALLEN, ARTHUR A.: "The Book of Bird Life," New York: D. Van Nostrand Company, Inc., 1930, pp. 402–413.

BAYNES, ERNEST HAROLD: "Wild Bird Guests," New York: E. P. Dutton & Company, Inc., 1915, 326 pp.

BOND, FRANK: "My Bird Boarders," Washington, D. C.: The Green Lamp League, 1933, 104 pp.

HERRICK, FRANCIS HOBART: "The Home Life of Wild Birds," New York: G. P. Putnam's Sons, 1901, pp. 117–137.

TRAFTON, GILBERT H.: "Methods of Attracting Birds," Boston: Houghton, Mifflin Company, 1910, 171 pp.

FINDING WHAT FOODS THE BIRDS LIKE BEST

Aims

Interest in bird life.

Appreciation and knowledge which lead to conservation.

Experience contributing to a concept of the interrelationships of living things.

Suggestions

Use both observational and experimental methods in discovering some of the food habits of a few of the commoner birds.

Look about for plants with fleshy fruits such as high-bush cranberry, elderberry, currant, honeysuckle, dogwood, thorn-apple, mountain ash, black haw, rose, apple, pear, plum, grape, ivy, and juniper. Keep records of the birds feeding on each.

Select some evergreens, and discover which birds are opening the cones to get the seeds. Note the shapes of the birds' beaks.

Visit a weed patch, and note the birds eating the seeds.

Discover what birds look about on the ground or scratch for their food. If possible, find out what they are getting.

Discover which birds search the trunks and branches of trees for insects. Note the type of beak that they have.

Arrange an experimental feeding shelf where the food preferences of the birds can be observed. Any box with low sides sufficient to keep the food from blowing or washing away is satisfactory. (Consult the references for plans for naturalistic feeding stations.) Experience shows that it is sometimes necessary to change the location of the shelf until a place is found where the birds will visit it.

Spread a variety of plant and animal food on it, such as grains, weed seeds, leafy foods (lettuce, celery, endive, etc.), buds, evergreen seeds, meat scraps, various kinds of insects, and worms. Watch carefully to see what each bird selects from the feeding shelf. If the shelf can be located where it will be visible from a window, the arrangement will be ideal.

Post pictures of the bird visitors in the schoolroom together with mounts or records of their favorite foods.

Let the children discuss the birds that scatter seeds to start wild fruits, those that get rid of many weed seeds. and those that destroy insects which would injure our plants.

Contributing Learnings

Some plants whose fruits are eaten by birds, and the number of kinds of birds seen eating each are;

Raspberry	118
Elderberry	106
Sumac	93
Dogwood	86
Wild grape	77
Wild cherry	74
Blueberry	67
Mulberry	52
Pokeberry	49
Strawberry	46
Holly	45
Juneberry	40
Hackberry	40
Virginia creeper	39
Juniper, red cedar	39
Smilax	39
Red haw	33
Black haw	28
Rose	25
Snowberry	25

Data from U. S. Dept. Agr. *Farmers' Bulletin* 1239.

The birds drop the seeds of many of these plants. New plants grow from the seeds. In this way plants such as raspberries become widely distributed.

A number of birds, including grosbeaks, crossbills, finches, and sparrows, are able to open the pine cones and eat the seeds. They do this with their thick wedge-shaped or scissor-like beaks.

Birds eat a great quantity of weed seeds. Sparrows, juncos, and goldfinches are common seed eaters.

Nuthatches, chickadees, woodpeckers, creepers, wrens, bluebirds, and a number of other common birds search the trees for insects. They have slender beaks which can be inserted into crevices in the bark and holes made by insects. Nuthatches spiral the limbs in the course of their search. Creepers creep up the trunk, then fly to the base of another tree.

Several common birds such as pigeons, sparrows, quail, horned lark, and meadow lark get most of their food on the ground, as do many of the game birds and poultry. Their food is partly animal (insects, worms, etc.) and partly plant (seeds, buds, shoots).

References

BOND, FRANK: "My Bird Boarders," Washington, D. C.: The Green Lamp League, 1933, 104 pp.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 72–116.

*DUPUY, WILLIAM ATHERTON: "Our Bird Friends and Foes," Philadelphia: John E. Winston Company, 1925, 319 pp.

*EATON, ELON HOWARD: "Birds of New York," Memoir 12, New York State Museum, Albany, N. Y.: University of the State of New York, 1910, 2 vols.

*GEHRS, JOHN H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 54–73.

HENDERSON, JULIUS: "The Practical Value of Birds," New York: The Macmillan Company, 1927, 290 pp.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush & Company, 1930, pp. 111–136.

*MATHEWS, F. SCHUYLER: "The Book of Birds for Young People," New York: G. P. Putnam's Sons, 1921, 320 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 69–80.

*PATTESON, S. LOUISE: "How to Have Bird Neighbors," Boston: D. C. Heath & Company, 1917, 131 pp.

*ROBERTS, THOMAS S.: "Birds of Minnesota," Minneapolis: University of Minnesota Press, 1932. 2 vols.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book II, Philadelphia: J. B. Lippincott Company, 1931, pp. 37–81, 112–115, 158–159.

*——— and ———: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company, 1931, pp. 6–60.

LEARNING TO KNOW THE COMMON TREES AND THEIR USES

Aims

Greater enjoyment of trees.

Appreciation which leads to the conservation and planting of trees.

Suggestions

Begin with trees in fall when the autumn coloration lures children to collect leaves. Continue the activity in winter, and learn to recognize the trees in their leafless condition. In spring, learn to know them in flower and fruit.

Press a collection of the leaves of the commoner trees, and mount them in a tree booklet or on a large card with paste. In the tree booklets, list the principal uses of each tree.

Leaf prints can be made in several ways. To blueprint leaves, arrange them on a piece of blueprint paper in subdued light. Lay the paper on a board, cover with a sheet of glass, and place in bright light for a few minutes. Then wash the paper with water. Very beautiful leaf prints showing a great amount of detail can be made as follows: Coat one fourth of a sheet of newspaper with lard, wiping off the excess with a cloth. Hold the larded paper over a candle until evenly sooted. Then lay a leaf on the paper, cover with a clean piece of paper, and rub with the tips of the fingers. Now transfer the leaf to mounting paper, again cover with a clean sheet of paper, and rub until a print of the desired intensity is produced. Many leaves can be printed without resooting the paper. The prints are permanent and do not smear.

Map the trees in the school ground, along a street, or in a small park or open woods.

Mount collections of the twigs in the winter condition, being careful to select twigs that have retained their buds.

Make a collection of wood samples from the common trees, planing the surface of each to show the grain. Cut them to a uniform size, and mount them in an attractive manner.

It will prove very interesting to take pictures or make sketches of the trees in winter. Add these to the tree booklets.

Collect the flowers and fruits of the trees in spring. Press them, and mount them beside the leaves and twigs of the trees. It will be necessary for the children to watch for the flowers of the basswood and possibly the catalpa after school closes. The fruits of these and of some of the other common trees can be obtained in fall. Others must be obtained in spring.

Let the children give the booklets a personal touch by adding the experiences that they have had with the common trees.

Encourage the children to write an account of "What Our Trees Mean to Us," with a view of arousing interest in preserving and planting trees in the community. Let them select one of these and submit it for publication in the local paper.

Make a general survey of the abundance of trees in the community. Discuss where trees ought to be planted and what species would be best. Encourage children to start trees at home. (See the spring activity "Starting Trees from Seeds.")

Read poems and stories about trees.

Contributing Learnings

The so-called hardwood trees have broad leaves; the softwoods, commonly needle or scalelike leaves. Most of the softwoods are evergreen, as they do not drop all of their leaves at any one time. Tamarack or larch and cypress are exceptions among the softwoods, being bare during the winter. The softwoods commonly bear naked seeds on the scales of their cones. Hardwoods bear seeds enclosed in a variety of types of fruits.

The conifer trees do not have showy flowers, the pollen and the ovules which later develop into seeds being borne on the scales of the tiny cones. They depend upon wind to carry the pollen to the ovule. Many of the hardwoods have showy flowers and are insect pollinated. Birches, poplars, willows, oaks, and beeches are largely wind pollinated. Their flowers are borne in catkins or strings which hang from the branches and are shaken about by the wind. They develop before the new leaves are grown. Many of the trees flower and fruit very early in the spring. Maples, willows, elms, and poplars are among the earliest. Elms flower and fruit, and the fruits scatter, long before most people think that spring has come. Catalpas and locusts remain in winter condition until late in the spring. Basswoods do not flower until summer.

We can learn to distinguish our trees most easily by noting certain characteristics. Buds occur in the axils of the leaves. Simple leaves have one blade. Compound leaves have three or more blades. Box elders, ashes, walnuts, butternuts, locusts, and mountain ashes have compound leaves. Most trees have alternate leaves (one at each node or height on the twig). Maples, ashes, buckeyes, and horse chestnuts have opposite leaves and branches. Catalpas have three leaves at each node. Leaves differ in shape, margin, and venation. By noting these differences, it is not difficult to recognize the common hardwood trees in leaf.

By noting the arrangement of the leaf scars where the leaves have fallen, and the differences between the buds, it is almost as easy to recognize these same trees in winter. Most of the conifers are easily recognized. Pines have needles in bundles. Spruces have separate four-angled needles. Firs have separate flat needles. Cedars have scales or awls, the leafy branches appearing slender and threadlike. Arborvitae has scales, the leafy branches appearing flat, fanlike.

Trees have many uses. Few of us realize how much they mean to us and how important it is to conserve and to grow them. Our forests are almost gone, and we have done very little to protect or restore them. We must prevent and control the fires that each year destroy many thousands of acres of growing timber. It is possible in most of the country for each home to have trees. Many trees in the parks are thoughtlessly destroyed by cutting and peeling the bark. (The uses of the various trees can be found in the references appended and in the encyclopedia. There is hardly space here to list them.)

References

*_Cornell Rural School Leaflet_, Vol. 20, No. 2: Babes of the Wood, Ithaca, New York: Cornell University, November, 1926.

Cornell Rural School Leaflet, Vol. 15, No. 2: Woody Plants in Autumn, Ithaca, New York: Cornell University, November, 1921.

*Craig, Gerald S., and Margaret G. Condry: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 284–309.

Curtis, Carlton C.: "A Guide to the Trees," New York: Greenberg, Publisher, Inc., 1925, 208 pp.

*Dougan, Lewis M.: "Stories of Outdoor Science," New York: Lyons and Carnahan, 1933, pp. 225–286.

*EMERSON, ARTHUR I., and CLARENCE M. WEED: "Our Trees—How to Know Them," Philadelphia: J. B. Lippincott Company, 1918, 286 pp.

*GEHRS, JOHN H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 137–161.

HAWKSWORTH, HALLAM: "A Year in the Wonderland of Trees," New York: Charles Scribner's Sons, 1926, pp. 39–95.

MATHEWS, F. SCHUYLER: "Field Book of American Trees and Shrubs," New York: G. P. Putnam's Sons, 1915, 450 pp.

OTIS, CHARLES HERBERT: "Michigan Trees," Ann Arbor, Michigan, University of Michigan, 1926, 247 pp.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 32–38, 76–81.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 80–101, 119–132.

*——— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 63–94.

ROGERS, JULIA ELLEN: "The Tree Book," Garden City, New York: Doubleday, Doran & Company, Inc., 1905, 589 pp.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 32–42.

LEARNING TO KNOW THE FALL WILD FLOWERS

Aims

Ability to find enjoyment in things not commonly appreciated.

Appreciation which makes for conservation.

Basic experience contributing to understanding of the importance of adaptations for effective reproduction and dispersal in the survival of species.

Suggestions

Some of the *Compositae*, which constitute such a large part of the fall flowers, bear superficial resemblance to one another. For this reason it is well to include only the commoner flowers which are easily recognized: asters, sunflowers, coneflower, yarrow and tansy, goldenrods, thistles, milkweeds, vervains, bergamot or horsemint, butter and eggs or wild snapdragon, mullein, and a few others.

Post the plates of these wild flowers in the schoolroom to help the pupils recognize them. Crush leaves of tansy, yarrow, and bergamot, and become familiar with their characteristic strong odors. Note the sandpaper-like roughness of the stems and leaves of the sunflowers, the prickles of thistles, the drooping ray flowers of the coneflower, the resemblance of wild snapdragon to the cultivated types, etc.

Discover whether these fall flowers grow mostly in the open or in the shady woods. Compare them in this respect with the early spring flowers, a large percentage of which are found on the forest floor.

Examine the plants to see whether they are tall, coarse, tough, and weedlike or tender and delicate like the spring flowers. Find out which kinds are considered to be only weeds. Arrange a beautiful bouquet of weeds that are commonly despised.

Examine the blossoms of sunflowers, asters, and other composites. Note that what appears to be a large flower is really a cluster of tiny flowers with often an outer circle of straplike showy ones. Observe the procedure of insects alighting on the flower heads. Let the children suggest possible advantages of this arrangement in heads when the insects visit the flowers.

Secure a ripened head of thistle, and examine the seeds (really fruits). Release the seeds, and watch them sail away. Examine the seeds to see why they are easily blown about. Make a collection of the fall flowers easily scattered in this manner. Tell the children that this family of plants with many flowers in a head on a single stem is the largest and most widely distributed family of plants, and let them suggest some possible reason why this is so.

Select some sunflowers and thistles for observation. Watch to see what becomes of the seeds. Post the pictures of the bird visitors. Let the children decide whether thistle bird is a good name for the goldfinch.

Enjoy the wild flowers through art, song, and poetry. Plant some goldenrods and asters in a corner of the school-yard by plucking some mature stalks and sticking them in the ground after clearing away all other competing vegetation. The seeds will fall to the ground, and many new plants will appear.

Compare the wild flowers with somewhat similar cultivated species.

Contributing Learnings

Most of the summer and fall flowers grow in the open. Light is generally necessary for flowering. Many of the early spring flowers appeared in the woods before the trees were in leaf.

The early spring flowers produced blossoms in a few days after they appeared above the ground. Most of them came from food stored underground in parts that lived over winter. The soft, delicate, juicy stems and leaves grew rapidly in the moderate sunlight and plentiful moisture of spring. Many of the fall flowers came from seeds. They have grown slowly throughout the hot, dry summer. They are hardy, tough, and not easily killed.

The flowers of many of the fall-blooming wild plants are arranged in heads. Each flower is tiny, but the flower head is usually quite showy. The straplike outer row of flowers (of many composites) is especially showy but does not produce seeds. Both plant and insects profit from this arrangement of flowers in heads. The insects are attracted by the showy mass of flowers. When they land on the flower head, they visit many of its flowers, sticking their tongues or sucking tubes into each

flower. In getting the nectar, they leave pollen which will cause the seeds to develop.

In addition to a good method of securing pollen, many of these fall flowers have an umbrella-like arrangement (pappus) attached to the top of each seed (fruit), which enables the wind to carry the seed long distances. These plants have spread over most of the earth. Scarcely an island in the ocean is without some of them.

The fall flowers are beautiful and should be left unharmed wherever they will not injure the plants that we must have for food for ourselves and our domestic animals. Where all of the land is cultivated, mowed, or burned over, the fall flowers are scarce. They will soon come in and seed themselves again if we leave waste lands and poorer soils in meadow. While it is better to leave wild flowers on the stalk for everybody to enjoy, there is little danger that the fall flowers will disappear with moderate picking. Unlike the spring flowers, they last well in bouquets. It is a good rule in picking always to leave some. Where it is necessary to control these plants, especially thistles, Spanish needles, and yarrow, they must be cut before they produce seeds.

From these fall flowers, which beautify our roadsides and meadows in summer and fall, many of our showiest garden flowers have been developed.

References

BLANCHAN, NELTJE: "Wild Flowers Worth Knowing," Garden City, New York: Doubleday, Doran and Company, Inc., 1917, 259 pp.

*BURGESS, THORNTON, W.: "The Burgess Flower Book for Children," Boston: Little Brown and Company, 1923, 338 pp.

*HOUSE, HOMER D.: "Wild Flowers," New York: The Macmillan Company, 1934, 362 pp.

*———: "Wild Flowers of New York," Memoir 15, Albany, New York: The University of the State of New York, 1923, 362 pp.

*———: Color plates (264) from Memoir 15, Albany, New York: The University of the State of New York, 1923.

KEELER, HARRIET L.: "The Wayside Flowers of Summer," New York: Charles Scribner's Sons, 1917, 274 pp.

*MATHEWS, F. SCHUYLER: "The Book of Wild Flowers for Young People," New York: G. P. Putnam's Sons, 1923, pp. 219–388.

*"The Book of Wild Flowers," Washington, D. C.: The National Geographic Society, 1933, 243 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Science at Home," New York: The Macmillan Company, 1934, pp. 3–19.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES, "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 27–30.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 65–70.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 55–61.

*——— and EDWARD E. WILDMAN, "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 38–46.

HOLDING A HARVEST FESTIVAL

Aims

Interest in the fall season and in the varied products of farm, garden, and orchard.

Experience contributing to the concept of our dependence upon plants.

Suggestions

In all but the northernmost regions of the country, the harvest festival may immediately precede Thanksgiving. In the northern states it should be held earlier in the fall when materials are more easily obtained. Even here it will serve to arouse interest in coming Thanksgiving activities. This project is equally important in cities where children have even less idea of the source of their foods.

The field crops are not highly perishable and may be collected and arranged first, leaving the more perishable types of fruits and vegetables to the last. A few stalks of corn may be set up to resemble a shock, and pumpkins placed around it. There should be small bundles of all local field-crop plants.

Let the children bring a great variety of vegetables and fruits and arrange them in an attractive manner about the room.

There is a sufficient variety of products in most localities to make a splendid display, and it is unwise to complicate the project with many foods from other regions.

Each child should learn to recognize all of these products and know something of the ways in which they are grown. Make a list of ways in which they are used. Prepare and serve some of the foods. Feed others to birds and other animals.

There is abundant opportunity for correlation with art, language, and music. A festival atmosphere should prevail.

Seed and nursery catalogues are especially good reference material. There are so many such companies in each state that it is not feasible to list them here. Many children can bring catalogues from home. A little inquiry will reveal other good firms in the region which will be glad to supply their catalogues. Horticultural journals, farm papers, and many magazines carry advertising by a large number of seed and nursery companies.

Contributing Learnings

In order to have all of these foods, many people have spent the spring, summer, and fall preparing the soil, planting, cultivating, laboring to protect the crop from insects and diseases, and gathering the harvest.

We depend upon the harvest for our food until another growing season.

Some of the harvest is used for our food—bread and other forms of cereal, vegetables, fruits, sweets, drinks, etc. A great deal of it is fed to the farm animals which furnish our milk, butter, meat, eggs, wool, and leather, and which did much of the work of growing our crops. Some is saved for planting again.

Harvest is a time of rejoicing over the fruits of our long labors.

The people in the city as well as those in the country depend for their food upon the farms.

We do not make our foods. Plants make food out of materials from the air and soil. They depend upon the sun's energy to do their work. Some of this sun energy is stored in the foods. So we, too, depend upon the sun. We can have more food and energy by learning how to make plants grow better.

(The specific information concerning the various products is too extensive to reproduce here.)

References

*Carpenter, Frank G., and Frances Carpenter: "The Foods We Eat," New York: American Book Company, 1925, 181 pp.

*Chamberlain, James Franklin: "How We Are Fed," New York: The Macmillan Company, 1923, 200 pp.

Davis, Kary Cadmus: "School and Home Gardening," Philadelphia: J. B. Lippincott Company, 1918, pp. 293–334.

Eaton, Jeanette: "Behind the Show Window," New York: Harcourt, Brace & Company, 1935, pp. 18–132.

Freeman, W. G., and S. E. Chandler: "The World's Commercial Products," Boston: Ginn and Company, 1908, 348 pp.

*Gehrs, John H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 1–53.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 61–93.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 1–38.

*Persing, Ellis C., and Elizabeth K. Peeples: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 76–82.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 48–54, 62–69.

*Rocheleau, W. F.: "Products of the Soil," Chicago: A. Flanagan Company, 1928, 192 pp.

*Worthington, Josephine, and Catherine Victoria Matthews: "Our Food," Dansville, New York: F. A. Owen Publishing Company, 1930, 256 pp.

FINDING BY EXPERIMENT AND OBSERVATION WHAT BECOMES OF THE SEEDS

Aims

A new avenue of interest and enjoyment.

Experience contributing to the concepts of interdependence, the balance of life, and survival through adaptation.

Suggestions

Select for observation a very few plants showing marked methods of seed dispersal. The following widely distributed plants are among the most suitable ones, but the list is merely suggestive. Other equally satisfactory ones may be more accessible.

Mountain ash, wild cherry, thornapple, strawberry, walnut, butternut, oak, hazelnut, elderberry, grape, milkweed, dandelion, thistle, sunflower, tickseed, Spanish needle, beggar lice, burdock, sand bur, wild touch-me-not or balsam weed, and Russian thistle.

Mark the plants in some manner, and watch for the gradual disappearance of the seeds in the various ways.

A number of interesting observational records will be accumulated by watching the plants, but the children should be encouraged to devise other methods of finding what becomes of the seeds. Try collecting seeds from the hairy coats of dogs and other animals. Throw seeds against fur to see which might stick to it and be carried in this manner. Examine wheat and other grain for weed seeds. Throw seeds into a vessel of water, and record which float and how long. Try feeding the seeds to pet mice, rats, chipmunks, squirrels, etc. Put them out on the bird-feeding shelf. Protect them from blowing away, and note which disappear. Drop the seeds in the wind or before an electric fan to see how far they are carried. Drop them on a hill or inclined plane to see which will roll away.

Put the results of the observations and experiments into some attractive permanent form which will show the methods of dispersal.

Interesting methods of organizing the plants according to the means of dispersal are described in the references.

Consider how far from the parent plants the baby plants may come up next year and what characteristics enable each to travel about and spread its kind over the earth.

Contributing Learnings

Seeds are produced in enormous numbers. Each seed contains a baby plant capable of growing into a plant somewhat like the parent. Seeds develop in fruits.

Many of the nuts and pine seeds are eaten by squirrels, which are also busy storing them away for winter. Mice, rats, and other animals eat the grains and store them in their nests. We haul the juicy fruits and the grains about and cause them to spread far and wide.

Grain and grass seed often contain weed seeds. Birds eat many weed seeds, grains, and fleshy fruits. They spread such plants as strawberries and raspberries through the woods.

The wind scatters many of the lighter seeds. Some wind-carried seeds have wings or balloon-like coverings. Others have light umbrella-like tops resembling parachutes and can float through the air for long distances. The ball-shaped plants become tumble weeds and scatter their seeds as the wind rolls them along.

Bur- and needle-like fruits stick to our clothing and to the coats of animals and are carried in all directions. The barbs on many such fruits are hooked.

Many seeds will float on water for a time and are washed about by the runoff from heavy rains. Some seeds are carried long distances by streams.

A few plants such as touch-me-not have fruit pods which pop open suddenly, especially when disturbed. The seeds of these plants are thrown some distance by the sudden twisting of the sides of the fruit pod.

Many plants lose their seeds early. Some carry part of them through the winter. Most of the seeds that are scattered in the fall do not come up until spring. If they are to grow into next year's plants, the seed babies must live through the wet season and the cold winter.

Most of the seed babies never have an opportunity to grow, but Mother Nature produces so many seeds that enough are almost certain to escape to cover the earth with new green plants

in the spring. There would not be room for all of the seeds to grow into plants.

Many animals and plants depend upon each other. Plants provide food. Animals distribute the seeds of plants and pollinate the flowers so that more seeds will be produced.

References

Cornell Rural School Leaflet, Vol. 20, No. 2: Babes of the Woods, Ithaca, New York: Cornell University, November, 1926.

**Cornell Rural School Leaflet*, Vol. 28, No. 2: Fruits of Woody Plants, Ithaca, New York: Cornell University, November, 1934.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 206–223.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson and Company, 1928, pp. 233–244.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 15–24.

*——— and ———: "The Nature Activity Readers," Book III: "The Outdoor World," Boston: Little, Brown and Company, 1931, pp. 61–76.

*FISHER, CLYDE, and MARION L. LANGHAM: "Nature Science," Book III: "Our Wonder World," New York: Laurel Book Company, 1934, pp. 52–63.

*FULTZ, FRANCIS M.: "The Fly-aways and Other Seed Travelers," Bloomington, Illinois: Public School Publishing Company, 1923, 186 pp.

*GORDON, EVA L., and JENNIE HALL: "Nature Stories for Children—An Autumn Book," New York: Mentzer, Bush & Company, 1926, pp. 1–25.

*JENKINS, OLIVER P.: "Interesting Neighbors," Philadelphia: P. Blakiston's Sons & Company, 1922, pp. 152–181.

MATHENY, WILLIAM A.: "Seed Dispersal," Ithaca, New York: The Slingerland Comstock Company, 1931, 141 pp.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book V, New York: Silver, Burdett & Company, 1935, pp. 26–33

*PATCH, EDITH M.: "First Lessons in Nature Study," New York: The Macmillan Company, 1927, pp. 47–63.

*WITHROW, VESTA: "The Story of Seeds," Columbus: American Education Press, 1935, 36 pp.

SAVING SEEDS FOR PLANTING

Aims

A new avenue of interest in plant propagation.

Useful knowledge of collecting and storing seeds.

Some understanding of the significance of seed time and of reproduction.

Suggestions

Open some large seeds such as lima beans, and find the baby plants. Soaking the seeds in water for a few hours makes them easy to open, although it is not necessary. Note that the seed contains not only the tiny plant but also stored food which will enable it to start its growth and coats to protect it.

The problem is to keep the baby plants alive in the seeds until spring when they can be started in flowerpots and boxes of dirt in the schoolroom, planted in a small garden or school nursery, or given to the children to plant in their home gardens. Any cool, dry, airy storage place will do. Such a place can be found in one of the homes if no suitable one exists at school.

Envelopes, cardboard boxes obtainable from stores for the asking, paper sacks, and cloth bags are satisfactory containers but need to be kept away from mice. A common method is to suspend the bags from a wire or cord.

A simple method used by some of the experiment stations is to spread the uncleaned moist vegetable seeds on sheets of paper. The seeds dry fast to the paper. The sheets are then folded, labeled, and filed.

Glass jars are especially desirable. A practically uniform set of salad-dressing and sandwich-spread jars can be secured from the homes without cost. It is well to punch a few small holes in the lid of each jar to admit air. If tin boxes or cans are to be used, perforate them.

No school is likely to collect, much less to plant, all of the seeds listed below; but the following suggestions may prove helpful and will certainly indicate the wealth of opportunity. Gather seeds of evergreens (pines, spruce, firs) before the cones start to open. The seeds usually fall out as soon as the cones open and are scattered by the wind. Take a few cones back to the school-

room. The seeds may be removed at any time. They are likely to drop out when the cones dry. They sometimes pop out in a most interesting manner.

Pick seeds of some of the broad-leaved deciduous trees such as mountain ash, hackberry, catalpa, basswood, ash, hickory, walnut, oak, locust, thorn apple, buckeye, horse chestnut, chestnut, Norway maple, and sycamore.

Many shrubs have seeds in autumn: lilacs, mock orange, black haw, high-bush cranberry, hazelnut, snowberry, wolfberry, coral-berry, sumac, prostrate junipers, dogwoods, elderberries, catoneaster, buckthorn, chokeberries, wahoo, flowering quince, pea tree, privet, and many others.

Be sure to save seeds for next year's vegetable gardens. Scrape seeds from tomatoes, peppers, muskmelons, watermelons, cucumbers, pumpkins, squashes, and citrons, and dry them well on blotters before putting them in the containers. Pick the dry seeds from peas, beans, lima beans, lettuce, radishes, etc. Secure a few ears of ripe sweet corn.

Pick seeds of zinnias, snapdragons, hollyhocks, sunflowers, marigolds, sweet peas, nasturtiums, asters, daisies, phlox, petunias, and other garden flowers.

Secure a supply of seeds of the commoner field crops: corn, wheat, oats, rye, clover, etc.

Seeds of the fall wild flowers, such as asters, goldenrods, cone-flowers, harebells, sunflowers, bouncing Bet, and evening primrose, may be included.

Many seeds, especially of the trees and shrubs, should be planted in the fall. Plant a few of each kind of seed in a bed out-of-doors, and discover which come up next spring. Plant some in a box of soil indoors. Save a considerable supply of each kind for school and home planting projects in the spring. Be sure to label all containers.

Contributing Learnings

We must collect our seeds for planting early, as birds, squirrels, and other animals eat most of the seeds of many plants.

Seeds grow in fruits which develop from flowers, except those of evergreen which are naked. Fruits are sometimes soft and will keep only a short time, but the seeds when ripe are rather dry and have firm coats.

In each seed is a baby plant together with stored food to start its growth. We like to eat this stored food but must save some seeds to start next year's plants. Mice, rats, and insects also feed on stored seeds, and it is necessary to protect our supply for planting from them.

The baby plants in the seeds are alive and need air as we do. They will start to grow whenever they get moisture and warmth, so it is necessary to store them in a cool, dry place.

Most seeds will not germinate well if planted at harvesting time. They need a rest period. We do not understand all of the changes that take place during the rest period and enable them to grow.

Some seeds need the effect of the freezing and thawing during the winter to soften the seed coats and let water in to the baby plants. Such seeds are best planted in the fall. Those which take up water quickly can be planted in the spring. Some seeds, such as those of junipers and cedars, often germinate the second or third year after planting.

References

Cornell Rural School Leaflet, Vol. 20, No. 2: Babes of the Woods, Ithaca, N. Y.: Cornell University, November, 1926.

*Persing, Ellis C., and Elizabeth K. Peeples: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 48–54.

Peterson, Maude Gridley: "How to Know Wild Fruits," New York: The Macmillan Company, 1914, 335 pp.

FINDING HOW WE GET OUR FOODS

Aims

Widening of interests.

Increased range of food habits. Decreased susceptibility to food fads and misleading advertising.

Experience contributing to a concept of interdependence among people and of the action of the sun on green plants as the support of life.

Suggestions

Let the children suggest a list of the foods they eat. Visit a grocery store, a general market, and a meat market, if possible, to discover other foods.

Clip pictures from seed catalogues and magazines of a great range of foods and their plant and animal sources. Mount them on large charts or in booklets.

Let each child show which foods he has eaten. See who has learned to eat the widest range of foods.

Find out which foods are produced in your community and where the others come from.

Talk about how the foods are obtained or processed. Look at pictures of the production, processing, and distribution of foods in reference books.

Visit gardens, farms, dairies, and wholesale houses to observe the production and handling of foods.

Name all of the occupations or types of workers concerned with supplying our food.

Discuss the green plants and the sun as the basic food makers.

Contributing Learnings

There are a great many foods. They come from plants and animals.

Foods are prepared from the roots, stems, leaves, juices, seeds, fruits, and even the flowers (cauliflower) of plants. Almost all of the organs of animals, the muscles, fat, and the secretions (milk, honey) are used for food. There are many food plants and animals. By eating a wide range of foods coming from the

various parts of many plants and animals, we are almost certain to get everything that we need to grow strong and healthy.

There are many untrue statements in food advertisements, and there are many food faddists who believe that certain foods have almost magic powers. The best plan is to eat a wide range of foods. Some of the foods that do not appeal to us at first later become our favorites. By learning to eat a wide range of foods we not only get what we need, but we are much better guests than those who are not educated in this respect.

A very large number of the people in the community (most of them in many communities) are engaged in providing our foods. In addition, we get foods from almost every other country. Without the work of all of the people who grow, haul, and sell these foods, we could not have the great array of things to eat that we now enjoy.

Plants really make all of this food, as the animals feed upon plants. The plants must have the energy of sunlight. So we depend upon the sun.

References

*Beauchamp, Wilbur L., Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 72–97.

*Camp, Ruth Orton: "The Story of Markets," New York: Harper & Brothers, 1929, 118 pp.

*Carpenter, Frank G., and Frances Carpenter: "The Foods We Eat," New York: American Book Company, 1925, 181 pp.

*Chamberlin, James Franklin: "How We Are Fed," New York: The Macmillan Company, 1923, 200 pp.

Comstock, Anna Botsford: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 275–307, 660–683, 736–742.

*Craig, Gerald S., and Sara E. Baldwin: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 79–94.

*——— and ———: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 48–58.

Fisher, Elizabeth F.: "Resources and Industries of the United States," Boston: Ginn and Company, 1923, pp. 33–98.

*Holtz, Grace M., and Jennie Hall: "Elementary Science," Book III, New York: Mentzer, Bush & Company, 1930, pp. 12–58.

*McCrory, Mae: "Plants That Give Us Food," Columbus: American Education Press, 1934, 36 pp.

*———: "Milk." Columbus: American Education Press, 1934, 36 pp.

*Patch, Edith M.: "First Lessons in Nature Study," New York: The Macmillan Company, 1927, pp. 1–12, 19–26, 63–67.

*——— and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 61–93.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 1–48, 159–168.

*——— and ———: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 365–421.

*PAYNE, GEORGE E., HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book I, Boston: Benjamin H. Sanborn & Company, 1927, pp. 171–175.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 60–64, 76–88.

*PETERSHAM, MAUD, and MISKA PETERSHAM: "The Story Book of Food," Philadelphia: The John E. Winston Company, 1933, 32 pp.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book I, Philadelphia: J. B. Lippincott Company, 1931, pp. 38–44, 54–57, 135–144.

*——— and ———: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company, 1931, pp. 62–69.

*WORTHINGTON, JOSEPHINE, and CATHERINE VICTORIA MATTHEWS: "Our Food," Dansville, New York: F. A. Owen Publishing Company, 1930, 256 pp.

FINDING HOW WE GET OUR CLOTHING

Aims

Widening of interests in plants, animals, occupations, and industrial processes.

Contribution to concepts of our dependence on plants, animals. and ultimately on the sun for our clothing and of our own interdependence.

Suggestions

Encourage the children to bring scraps of as many types of clothing materials as possible. Let them trim and neatly mount samples of silk, wool, cotton, linen, rayon, rubber, leather, straw fabric, jute, felt, furs, paper (from certain types of summer hats), and feathers.

If possible, children in the city schools should visit a farm to see the plants and animals that furnish our clothing. In village and rural schools, children can bring samples of the plants. Bring in larvae of some of the giant silkworm moths (see suggestions for the activity "Rearing Insect Larvae"), and watch them spin silk. Dip a discarded cocoon into warm water, and try to unroll the silk.

Mount pictures of the plants and animals beside the samples of clothing materials.

Do simple weaving. Get someone to show how hides are tanned to make leather. Dye fabrics.

Talk about the processes of making clothing. Try to find out where the plants and animals used for our clothing are grown and where the clothes are made.

Discuss our dependence upon all of the people engaged in supplying our clothing, upon the plants and animals, and upon the sun.

Contributing Learnings

We get our clothing from plants and animals.

The common silkworm-moth larva spins silk which we use for dresses, shirts, underclothing, hosiery, neckties, etc.

Cattle- and horsehides are made into leather for shoes, jackets, gloves, mittens, etc. The skins of kangaroos, wild hogs, alliga-

tors, and snakes are also used for leather, although frequently imitated.

Rabbit hair is made into felt for hats, and the furs are widely used for coats and trimming.

The wool of sheep is woven into almost all types of garments. The skins are used for linings and for moccasins.

Muskrat, skunk, seal, raccoon, lamb (Persian), beaver, and mink skins are made into fur coats. Many of these as well as weasel, fox, lynx, and other furs are used for trimming.

Indians and many white people highly prize deerskins for clothing.

The cotton about the seeds of the cotton plant is probably the most frequently used of all clothing materials.

The fibers of the flax plant are made into linen which is used for collars and for summer dresses and suits. Some collars are made of jute.

Wood pulp and cotton are made into rayon which has many of the same uses as silk.

The sap of rubber plants gives us rubber for boots, aprons, raincoats, etc.

Straw, principally rye, affords us our summer hats.

Feathers of birds are sometimes used as decoration on women's hats. The dyed feathers of domestic fowls are mainly used now. Formerly, feathers were obtained from wild birds. The beautiful egrets were slaughtered for this purpose.

References

ALLEN, NELLIE B.: "Cotton and Other Useful Fibers," Boston: Ginn and Company, 1929, 368 pp.

*BEAUCHAMP, WILBUR L., HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 98–99.

*CARPENTER, FRANK G., and FRANCES CARPENTER: "The Clothes We Wear," New York: The American Book Company, 1926, 198 pp.

*CHAMBERLIN, JAMES FRANKLIN: "How We Are Clothed," New York: The Macmillan Company, 1923, 189 pp.

FISHER, ELIZABETH F.: "Resources and Industries of the United States," Boston: Ginn and Company, 1923, pp. 100–117.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush and Company, 1930, pp. 147–158.

*LANSING, MARION FLORENCE: "Great Moments in Science," Garden City, New York: Doubleday, Doran & Company, Inc., 1926, pp. 71–89.

*McCRORY, MAE: "Clothes," Columbus: American Education Press, 1934, 35 pp.

*PATCH, EDITH M.: "First Lessons in Nature Study," New York: The Macmillan Company, 1928, pp. 114–136, 150–170.

*——— and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 1–60.

*——— and ———: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 267–364.

*PETERSHAM, MAUD, and MISKA PETERSHAM: "The Story Book of Clothes," Philadelphia: John E. Winston Company, 1933, 33 pp.

*VAN AMBURGH, DELLA: "Silk," Columbus: American Education Press, 1934, 35 pp.

*WORTHINGTON, JOSEPHINE, and CATHERINE VICTORIA MATTHEWS: "Our Clothing," Dansville, New York: F. A. Owen Publishing Company, 1931, 256 pp.

HOLDING A FALL FLOWER SHOW

Aims

Enjoyment of flowers. Interest in flower culture.

Conservation of wild flowers.

Experience contributing to the concept that we can modify the nature of plant and animal forms.

Suggestions

It is better to include only garden flowers, thereby fostering conservation of the wild flowers.

Olive and pickle jars make good display vases. Urge that the flowers be cut with long stems and some foliage, in order to acquaint the children with the plants and to make a more attractive display. Teachers in the central districts of the larger cities can usually make arrangements to visit a city park or greenhouse and secure specimens gratis. In most localities children can bring all of the flowers from their homes or from the garden of some neighbor who is an ardent flower lover. Flower lovers are usually proud of their gardens and are glad to contribute to such a display.

Secure from various sources a number of specimens of each kind showing variation in shades of color, doubleness, fringing and curling of petals, etc.

Learn the names of the flowers, ignoring names of varieties but noting the varying types that man has developed. Compare with some wild varieties of the same type, as wild asters and cultivated ones.

Practice arranging the flowers in attractive bouquets and color schemes.

Learn how the different kinds of flowers are grown, and plan to grow some for exhibit at the school fair next year. Look for the developing seeds among the flowers.

After interest has been aroused through the flower show, the class may decide to dig up and pot some of the fall flowers before frost kills them. Take them up with plenty of soil, and bring them into the schoolroom to continue flowering. Select young plants, and cut them back a little after you transplant them to the pots. Some of the plants that will continue blooming if

handled in this manner are salvia, petunia, fuchsia, lobelia, geranium, alyssum, vinca, nasturtium, and balsam. Transplant coleus for colored foliage.

Contributing Learnings

There are a great many common fall garden flowers to enjoy, for example: aster, chrysanthemum, daisy, gladiolus, geranium, cornflower or bachelor's-button, marigold, moss rose, gaillardia, hollyhock, rose, common pink and carnation, snapdragon, larkspur, petunia, sweet alyssum, calendula, canna, zinnia, cosmos, phlox, nasturtium, verbena. Anyone having a little space can grow some of these.

There are many less common flowers to grow, and others that bloom earlier in the season and therefore are not represented in our fall flower show.

Man has developed many varieties of each kind of flower. Most wild flowers are single, but many of the new types that we have developed are double and differ in color, size, and form from the wild ones. These new varieties show that it is possible to change plants in many respects.

Seeds develop from flowers. We can save the seeds to grow more flowers. Flowers can also be started from cuttings or slips.

It is better to grow the flowers that we desire to cut for bouquets and to leave the wild flowers to produce seeds.

References

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 613–659.

Cornell Rural School Leaflet, Vol. 25, No. 4: Garden Flowers, Ithaca, New York: Cornell University, March, 1932.

*GEHRS, JOHN H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 48–53.

*———: "Nature Study," Book II, New York: American Book Company, 1930, pp. 148–152.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 3–38.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 29–35, 89–93.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., pp. 62–79, 289–294.

*STEVENS, G. A.: "Garden Flowers in Color," New York: The Macmillan Company, 1935, 310 pp.

TAMING ANIMALS AND LEARNING THEIR WAYS

Aims

Enjoyment and appreciation of animals.

Desirable attitudes toward animals.

Experience contributing to concepts of interdependence and of man's partial control over other forms of life.

Suggestions

In most localities squirrels are the most suitable animals for the project, although chipmunks, cottontail rabbits, and many other mammals can be tamed. Even snakes can be tamed until they come for their food. Taming birds may well be a separate project.

The easiest way to tame any animal is to get it when it is young and rear it as a pet. This is especially true of rabbits. However, squirrels and chipmunks can easily be tamed after they are fully grown.

This activity may be carried on at the homes of the children if there are no squirrels near the school.

The first step is to collect a large store of acorns, hickory nuts, walnuts, pecans, or hazelnuts. Peanuts will do. Toss a few acorns or nuts to the squirrels when they come into the school or home yard. Do not be discouraged when the squirrels run away frightened, for they will soon come back if you will remain indoors to observe. After being fed in this manner for a time, they will show little fear when the acorns are tossed to them, and you will be able to remain out-of-doors to watch them. Throw out the acorns with as little body movement as possible, and remain quiet. The squirrels will soon lose their fear and come quite close to get the food. After a few more days of feeding in this way, hold the acorns in your hand. Squirrels tamed in this way will learn to come to you if you stand still and will even search your pockets for food if you make a practice of carrying acorns with you. Do not have children try to hold squirrels.

Chipmunks can be tamed similarly, but it is better to confine rabbits in an enclosure for a few days. They should be fed green vegetables and a little grain. Suspend nuts from a support with

various lengths of string to discover whether chipmunks will find a way to get them.

It requires a great deal of patience to tame an animal, but it is a delightful educational experience which every child should have. Once the squirrels are tamed, the children will have many interesting experiences with them.

Tell the children how we got our common domestic animals.

Contributing Learnings

We have taught wild things to fear us. We can also teach them not to be afraid of us and can thus enjoy them and study their ways.

Snakes and other animals are easily frightened during the taming period. If we handle them in a rough or nervous manner, they become excited easily and try to bite us; but if we are slow and gentle in our movements, they seem to understand that we will not harm them.

Squirrels are very interesting pets. They soon learn that we will not hurt them and will even search our coat pockets for nuts if we have patience. It is not necessary to pen squirrels in cages, as some people do, if we wish to have them for pets.

Squirrels have many interesting ways. One of their habits has been especially important. By burying acorns, they are thought to have been the chief agents in the spread of oak trees over much of the earth.

Chipmunks make interesting pets. They learn quickly. If nuts are suspended from strings (first within reach from the ground and later on very short strings), they learn to climb the support and to pull up the string hand over hand to get the food.

Rabbits become tamer than many other wild animals and make excellent though less interesting pets. Many people grow rabbits for their furs and for food. These are kinds that have been tamed for a long time.

We got our horses, cattle, sheep, dogs, cats, poultry, and other animals by taming them.

References

*BIANCO, MARGERY W.: "All About Pets," New York: The Macmillan Company, 1930, 134 pp.

COMSTOCK, ANNA BOTSFORD: "The Pet Book," Ithaca, New York: The Comstock Publishing Company, 1915, 301 pp.

*Craig, Gerald S., and Sara E. Baldwin: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 209–221, 246–249.

Cram, William Everett: "Little Beasts of Field and Wood," Boston: Small, Maynard & Company, 1899, 261 pp.

———: "More Little Beasts of Field and Wood," Boston: Small, Maynard & Company, 1912, 303 pp.

Downing, Elliot R.: "Our Living World," Chicago: University of Chicago Press, 1924, pp. 191–233.

*Dunn, Fannie Wyche, and Eleanor Troxell: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 7-21, 85-104.

*——— and ———: "Mother Nature Series," Book III: "In Field and Forest," New York: Row, Peterson & Company, 1928, pp. 5-71.

Eifrig, C. W. G.: "Our Great Outdoors—Mammals," Chicago: Rand-McNally & Company, 1928, 240 pp.

Finley, William Lovell, and Irene Finley: "Wild Animal Pets," New York: Charles Scribner's Sons, 1931, 311 pp.

*Gordon, Eva L., and Jennie Hall: "Nature Stories for Children—An Autumn Book," New York: Mentzer, Bush & Company, 1926, pp. 44–60.

*Jenkins, Oliver P.: "Interesting Neighbors," Philadelphia: P. Blakiston's Sons & Company, 1922, pp. 1–26.

Moseley, Edwin Lincoln: "Our Wild Animals," New York: D. Appleton-Century Company, Inc., 1927, 297 pp.

Nelson, E. W.: "Wild Animals of North America," Washington, D. C.: The National Geographic Society, 1930, 249 pp.

*Troxell, Eleanor, and Fannie Wyche Dunn: "Mother Nature Series," Book I: "Baby Animals," New York: Row, Peterson & Company, 1928, 160 pp.

DISCOVERING AND STUDYING ANIMAL HOMES

Aims

New avenues of interesting observation and enjoyment.

Experience contributing to the concept of survival by adjustment to natural conditions.

Suggestions

Make a class study of one type of animal home, and interest the children in searching for others. Let the child who discovers each home lead the class to visit it, if it is near at hand. Many of the deserted homes can be brought to school to be studied and then added to the museum. Still others can be observed and described by the children. Consider the purposes for which the homes are used. A few of the many possible observations are listed below.

Squirrels.—Look for the leafy summer nest and the hole in the tree.

Birds.—Find deserted nests. Observe materials and construction. Look for bird homes in holes in trees and posts. Compare with the bird houses that man has made.

Ants.—Expose an ant nest by overturning stones or other objects on the ground. Note the tunnels in the ground. Observe the ants carrying their young to safety, as people do when they are in danger. After examining the nest, carefully replace the object in order not to break up the home.

Gall Insects.—Collect galls from goldenrods, willows, oaks, and other plants. Open a deserted willow cone-gall home, and study it. Learn from Edna Patch's "Hexapod" stories the true story of "Cecid Cid Domy," the cecidomyiid fly which occupies it.

Bees.—Visit a beehive, and get the beekeeper to show you the inside of it. Better still, start an observation hive. Look for wild-bee nests, and compare.

Wasps.—Bring in abandoned homes of mud daubers and paper-making wasps for study.

Fall Webworm.—The web covers a number of twigs and is easily recognized. Bring in the entire branch.

Spiders.—See how many types of spiders webs you can find. Observe in what ways the spider uses his web.

Crayfishes.—Observe the raised mud homes of crayfishes along a stream.

Water Animals.—Examine a muskrat mound and runway.

Fishes.—Look for former sunfish nests which appear as clear spaces among the dense vegetation in the shallow water of lake margins.

Homes of Burrowing Animals.—Look for insect, snake, and gopher holes in the ground. Poke a flexible wire down the holes to discover how far they extend. Examine rabbit burrows and compare with the ones made by woodchucks or ground hogs.

Domestic Animals.—Examine the homes of horses, cattle, sheep, and dogs. Note that we have built homes for them somewhat like our own.

Miscellaneous.—Hollow trees and stems, rolled leaves, decaying logs, objects lying on the ground, trash piles, and many other places furnish homes for interesting creatures.

Contributing Learnings

There are myriads of animal homes. They are found in the ground, under objects, in trash, in plant stems, under the bark, in leaves, attached to plants and buildings in various ways, in the water, and almost all other conceivable places. The homes are made of a great variety of materials.

Most homes are places where young are reared. In addition, they may serve as protection against unfavorable weather and enemies.

Some animals build their homes. Others use hollow trees, holes under rocks, and other places that they are able to find. Rabbits commonly adopt deserted woodchuck burrows.

Injury to a plant usually causes it to enlarge. In this way the galls are formed which serve as homes for the attacking insects.

Many animals are very skillful builders. It seems wonderful that without being taught how to build they set about the task so readily. All of the animals of any one kind, as a rule, build much the same type of home. Some of them will use whatever materials are close at hand, but most of them have definite ways of building. Altogether they use a great many kinds of material in building their homes including sticks, leaves, grasses, bark,

mud, sand, rags, straw, string, down, paper, and body secretions. The construction of these various types of homes is interesting, but it would require too much space to describe them here.

Other animals do not have homes. They move about and seek protection wherever they may be when storms occur or enemies approach.

References

*BEAUCHAMP, WILBUR L., HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book III, Chicago: Scott, Foresman Company, 1936, pp. 96–111.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 213–260.

Cornell Rural School Leaflet, Vol. 23, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1929.

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 31–56.

CRAM, WILLIAM EVERETT: "Little Beasts of Field and Wood," Boston: Small, Maynard and Company, 1899, 261 pp.

———: "More Little Beasts of Field and Wood," Boston: Small, Maynard and Company, 1912, 303 pp.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson and Company, 1928, pp. 53–63, 133–177, 223–231.

*——— and ———: "Mother Nature Series," Book III: "In Field and Forest," New York: Row, Peterson and Company, 1928, pp. 7–51, 63–105, 116–124, 145–169, 173–232, 259–289.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book III, "The Outdoor World," Boston: Little, Brown & Company, 1931, pp. 179–183, 209–217.

*GEHRS, JOHN H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 123–127.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush & Company, 1930, pp. 111–136.

MOSELEY, EDWIN LINCOLN: "Our Wild Animals," New York: D. Appleton-Century Company, Inc., 1927, 297 pp.

*PATCH, EDITH M.: "First Lessons in Nature Study," New York: The Macmillan Company, 1928, pp. 188–261.

*———: "Hexapod Stories," Boston: Little, Brown & Company, 1920, pp. 35–46.

*——— and HARRISON E. HOWE: "Nature and Science Readers," Book I: "Hunting," New York: The Macmillan Company, 1932, pp. 3–38.

*PAYNE, GEORGE E., HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book I, Boston: Benjamin H. Sanborn & Company, 1927, pp. 7–12, 151–156.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 25–28, 101–106, 175–183.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 6–11, 39–47, 201–209, 228–231.

*——— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 8–29, 105–124.

*PHILLIPS, MARY GEISLER and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book I: "Some Animals and Their Homes," Boston: D. C. Heath & Company, 1936, 142 pp.

*——— and ———: "Nature—By Seaside and Wayside," Book III: "Plants and Animals," Boston: D. C. Heath & Company, 1936, pp. 141–149.

SCHMIDT, KARL PATTERSON: "Homes and Habits of Wild Animals," New York: M. A. Donohue and Company, 1934, 64 pp.

SETON, ERNEST THOMPSON: "Life Histories of Northern Animals," New York: Charles Scribner's Sons, 1909, 1200 pp.

STONE, WITMER and WILLIAM EVERETT CRAM: "American Animals," Garden City, New York: Doubleday, Doran & Company, Inc., 1902, 300 pp.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book II, Philadelphia: J. B. Lippincott Company, 1931, 186 pp.

*——— and ———: "Early Journeys in Science," Book III, Philadelphia. J. B. Lippincott Company, 1931, pp. 72–85, 163–176.

*TROXELL, ELEANOR, and FANNIE WYCHE DUNN: "Mother Nature Series," Book I: "Baby Animals," New York: Row, Peterson and Company, 1928, 160 pp.

WEED, CLARENCE M.: "Insect Ways," New York: D. Appleton-Century Company, Inc., 1930, pp. 167–183.

*WHITE, MARGARET L., and ALICE HANTHORN: "Do and Learn Readers," Book II: "Stories of Animals and Other Stories," New York: American Book Company, 1930, pp. 215–241.

WATCHING ANIMAL ATHLETES PERFORM

Aims

Enjoyment of animal life.

Experience contributing to the concept of existence through adaptation. Very elementary introduction to the concept that man and other higher forms of animals show relationships in their similar structural plan.

Suggestions

Watch the hopping of a pet rabbit, a frog, toad, and grasshopper. Note how well the muscles of the hind legs are developed for this form of movement. Drop the toad and frog into the water, and discover how they swim.

Observe the different movements of horses in walking, trotting, galloping, pacing, and running. Discover what other animals move about on four legs. See what uses the different animals make of their legs other than to carry them about.

Watch the movement of various insects, daddy longlegs, spiders, centipedes, and millipedes, and try to discover how they use more than four legs.

Walk on all fours. Lift one foot or hand from the floor, and notice how easy it is to keep your balance. Now stand erect, and take a step. Try to stand still balancing yourself on one foot. See what different uses we can make of our front limbs while moving about. Observe birds on the ground, and note that they also walk about on only two legs. Compare their front limbs with those of other animals and with our own, noting the uses made of them.

Watch the goldfishes and minnows swimming about in the aquarium. Discover that they swim by means of their tails, using the fins mostly for balancing. Disturb a crayfish, and watch him swim backward by suddenly doubling the tail under and bringing it forward with a quick motion. Watch backswimmers, water boatmen, and diving beetles as they swim about in the aquarium or in some pond. Note that the backswimmers swim upside down and that all three types have legs that resemble oars in appearance and use. Watch water birds swim. Examine the feet of a duck.

Listen to the hum of the bees hovering about the flowers, and notice how fast their wings are flapping. Note that bumblebees flap their wings at a much slower rate than do the honeybees and produce a correspondingly lower pitched droning hum. Observe beetles' wings at rest and in flight. Note that the outer pair are extended in flight and serve as planes, while the underwings are soft and flap to propel the body forward.

Watch the various birds in flight. Observe the slow flapping of the crow's wings and the rapid wing motion of swallows and swifts. Note the dipping, swirling, sailing, and other motions of snowbirds, swallows, chimney swifts, and hawks. Watch birds take off and land. Compare bird and insect flights with those of airplanes.

Let an earthworm crawl on your hand, and notice how he thrusts the front part of his body forward, then sets his spines and drags up the rear portion. Observe a snake, and compare its movements with those of an earthworm.

Observe other animals swimming in the water, flying, or moving about on land. Note which animals can move about in all three of these ways.

Contributing Learnings

Animals with many legs (millipedes have two pairs per segment, centipedes one pair per segment, crayfishes a pair on most segments, spiders four pairs in all, insects three pairs) always have enough legs on the ground to balance themselves, even while some of the legs are lifted in walking. Insects move the front and hind leg on one side and the middle leg on the other side while they balance themselves on the other three (a similar tripod). The extra legs are also used for many other purposes. Some animals with many legs move them in rapid order and can run rapidly for creatures with such short legs.

Most four-legged animals move the front leg on one side followed by the hind leg on the other, but there are many variations. Some animals (frogs, toads, rabbits, some insects) have especially well-developed hind legs which they use for making long leaps. For their size they are wonderful jumpers.

Turtles have very short legs and cannot run fast enough to escape their enemies but depend on their hard outer covering for protection.

Wading birds have long legs. The feet of most swimming birds are webbed and make good paddles.

Some animals (birds, monkeys, man) move about on only two legs, leaving the front limbs free for other purposes. The front limbs of birds are used for flight. We call their front limbs wings. Many birds are strong fliers, able to make long flights or to escape swiftly. Some birds dart about catching their food while on the wing. Hawks sail about looking for food. Some birds and some insects can fly, swim, and travel on land. The ground birds can run more rapidly than other birds but do not always fly so well.

The more rapidly an insect flaps its wings the higher pitched becomes the hum produced.

Some animals such as snakes and worms have neither legs nor wings. They thrust the head end of the body forward and then drag up the rear portion. They have muscles to make them long and slender or short and thick. Most of them move rather slowly, although some snakes can attain a good speed.

Nearly all of the animals that we see have some way of moving about. Some of the smaller water animals are attached and wait for food to come to them. A few insects such as the scale insects remain quiet, sucking the juices of the plant during most of their lives.

Animals need to move about for many reasons. The most important of these are to get food, to find mates, to find homes and places to lay their eggs, and to escape danger.

There are animals that can outrun us, some that can jump farther and higher, and many that are better swimmers and divers. Many animals can fly.

References

*Beauchamp, Wilbur L., Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book III, Chicago: Scott, Foresman & Company, 1936, pp. 13–46, 80–127, 212–215.

Brearley, Harry Chase: "Animal Secrets Told," New York: Frederick A. Stokes Company, 1911, pp. 163–191.

Cram, William Everett: "Little Beasts of Field and Wood," Boston: Small, Maynard & Company, 1899, 261 pp.

———: "More Little Beasts of Field and Wood," Boston: Small, Maynard & Company, 1912, 303 pp.

**Cornell Rural School Leaflet*, Vol. 21, No. 4: How Things Move and Are Moved, Ithaca, New York: Cornell University, March, 1928.

*CORY, HARPER: "Animals All," New York: Charles Scribner's Sons, 1933, 128 pp.

*DUPUY, WILLIAM ATHERTON: "Our Animal Friends and Foes," Philadelphia: John C. Winston Company, 1925, 274 pp.

*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 84–89.

MOSELEY, EDWIN LINCOLN: "Our Wild Animals," New York: D. Appleton-Century Company, Inc., 1927, 297 pp.

NELSON, E. W.: "Wild Animals of North America," Washington, D. C.: The National Geographic Society, 1930, 254 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book I: "Hunting," New York: The Macmillan Company, 1932, pp. 107–155.

*——— and ———: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 171–174.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 285–290.

*PHILLIPS, MARY GEISLER and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book I: "Some Animals and Their Homes," Boston: D. C. Heath & Company, 1936, 142 pp.

SETON, ERNEST THOMPSON: "Life Histories of Northern Animals," New York: Charles Scribner's Sons, 1909, 1200 pp.

*STEPHENSON, MARY BOWEN: "The World of Animals," Chicago: Thomas S. Rockwell Company, 1930, pp. 85–94.

STONE, WITMAR, and WILLIAM EVERETT CRAM: "American Animals," Garden City, New York: Doubleday, Doran & Company, Inc., 1902, 300 pp.

*WHITE, MARGARET L., and ALICE HANTHORN: "Do and Learn Readers," Book II: "Stories of Animals and Other Stories," New York: American Book Company, 1930, pp. 30–58.

WATCHING ANIMALS FEED

Aims

Interest in animal life.

Experience contributing to concepts of the struggle for food as the chief problem of animal life, of adaptation, and of interrelationship.

Suggestions

Raise the question as to whether all animals eat and drink as we do. Get the children interested in observing how the different animals eat and drink and what food each takes. Some of the animals can be kept in the schoolroom for study. Other observations must be made at home or on special field trips to observe the larger animals.

Sparrows or Other Seed-eating Birds.—Pick pods from some of the weeds. Place them on the feeding shelf, and watch the birds open them to get the seeds. Notice the shape of the beak.

Wren, Nuthatch, or Other Insect-eating Birds.—Thrust suet into the narrow cracks in the bark of a tree, and watch the birds insert their slender beaks into the crevices to get it. Compare the shape of beak with that of a sparrow.

Chicken.—Give the chicken a drink and watch it raise its head to swallow. Watch a chicken trying to swallow a grasshopper.

Duck.—Put some corn or other food in water, and watch the duck get it. Notice how the strainer works. Examine it.

Owl.—If there is a pet owl in the vicinity, give it a dead mouse. Watch it swallow the mouse whole and, sometime later, spit out the fur and bones in the form of a pellet.

Baby Birds.—Recall how the baby robins were fed.

Cat and Dog.—Watch them drink. Give them a piece of meat, and watch them eat it. Examine their teeth.

Squirrels, Chipmunks.—Watch them use their front feet to hold food, much as we do our hands. Observe how they chew away the hull of a nut with their strong sharp teeth.

Cow.—Watch the cow gather in a quantity of grass with her rough tongue. Notice how she chews off the grass. Get

someone who has a gentle cow to show you the cow's teeth. Observe the cow sucking up large draughts of water. Watch cattle chewing their cud. Tell the children about this interesting feeding habit.

Horse.—Observe the horse eating grass. Notice that he uses his upper lip to pull in the grass, whereas the cow uses her tongue. Get some one who owns a horse to show you its teeth. Observe the cutting teeth and the heavy grinders. Find what dry food the horse is fed. Watch horses drink.

Toads, Frogs.—Keep in a screened box on moist soil. Put a shallow flowerpot saucer of water in the cage, and watch these animals partly submerge themselves in the water to absorb it. Release some flies or other small insects in the cage, and watch very closely to see how the toad and frog eat. Watch the tadpoles sucking the algae and other scummy growth from the sides of the aquarium.

Gartersnake or Other Small Pet Snake.—Give the snake an earthworm, and watch how he swallows it. If you have a small dead fish, frog, or tadpole, discover whether or not the snake can swallow it.

Grasshopper.—Watch a grasshopper or locust astride a blade of grass. Observe whether his jaws move up and down as he eats, as ours do. By potting some of the grasses, these observations can be carried on indoors.

Butterflies.—Watch a butterfly visiting a flower. Catch one, and pull the long coiled sucking tube out where you can see it by thrusting an object through the center of the coil. This will not injure the butterfly. Feed butterflies a very thin syrup.

Bee.—Watch a honeybee or bumblebee on a flower. Note that he has a tongue which he thrusts out and uses somewhat as does a cat.

Flies.—Put a few grains of sugar on the window sill, and watch the flies eat it. Notice that it becomes moist and is taken in liquid form into the spongelike end of the fly mouthpart.

Larvae.—Bring in a cabbage plant infested with cabbage-butterfly larvae, and watch the feeding process. Examine the hooks of their rasping mouth parts.

Fishes.—Drop small pieces of fish food or a few flies into the aquarium, and watch the fishes dart to the surface and suddenly swallow them.

Contributing Learnings

The chief problem of animals is obtaining food. Most of their time is spent in food getting. This is especially true of some animals, such as cows and certain insects, which live on green plants not rich in food value.

Most animals eat only certain kinds of food. Some animals eat only plant foods; others, only animal foods. A few, including ourselves, eat both. Many animals eat each other. If this were not so, houseflies, mosquitoes, and many other forms of life would be almost unbearable. Animals are not cruel because they eat others. It is their only way of getting food.

The method of eating and drinking depends upon the structure of the mouth parts.

Some birds have short, thick, wedge-shaped beaks with which they open seed pods and pine cones. They are largely seed eaters. Other birds have long, slender, sharp beaks which they use to pick insects from holes and crevices. Birds do not have teeth with which to hold live insects and other animals. They must gulp them down quickly before they escape. The woodpecker's tongue is sharp and barbed, somewhat like a fishhook. By thrusting the tongue into an insect, the woodpecker is able to pull it from its burrow. Owls swallow mice and other animals whole. They digest the flesh and spit out such parts as the hair and bones in the form of a wad or pellet. Many baby birds are fed by the mother, father, or both. It is a common sight to see the baby birds with necks stretched upward and mouths wide open while the mother bird thrusts her own beak down the throat of the young one to deposit the food. Wading birds have long legs, long necks, and long beaks. Ducks have spoonlike beaks. The holes in the lower half make the beak a strainer.

Cats, dogs, and certain other animals use the tongue to lap up liquids. They also have long sharp teeth with which they tear the flesh apart. There is little development of teeth for grinding plant foods.

Squirrels, chipmunks, and some other animals have strong sharp teeth with which they chew the hard hull from a nut or strip a tough pine cone. The squirrels and chipmunks are among the animals that use their front feet to hold the food, much as we use our hands. We grasp objects between the thumb and fingers of the hand, while they must use both front feet.

With her long rough tongue the cow draws in a mouthful of standing grass. Then by pushing her head forward she partly tears and partly cuts off the grass with her lower teeth. She has no upper teeth. She swallows great quantities of grass without chewing it. Then she finds a shady place and brings cud after cud of the grass up from her stomach into her mouth to be thoroughly chewed. The food is now swallowed a second time and digested. Her stomach has four divisions.

Horses use the upper lip to pull the grass into their mouths to be cut off by the teeth. They cut the grass with a movement of the head toward the body, while cows eat away from the body. Both cattle and horses drink by "sucking up" large amounts of water.

Toads and frogs have sticky tongues attached near the front of the mouth. When an insect comes near, there is a flash of pink as the tongue flies out swiftly to catch it. Frogs and toads do not drink as most other animals do. Instead, they settle down in the water and absorb it through their skins. The young tadpoles have sucking mouths and feed largely on tiny plants.

The teeth of snakes are slanted backward and serve to hold the prey. The lower jaw is hinged so that it can open very wide to swallow animals much larger than the head of the snake.

Some insects chew solid foods. Others suck liquids. Some sucking insects, such as the mosquitoes, can pierce a hole and then suck the juices. Other sucking insects, such as butterflies, are unable to pierce and must find exposed liquid food. The jaws of chewing insects work sidewise, instead of up and down. Larvae have rasping mouths with hooklike projections which break up the food.

Many fishes catch living food which they swallow with one movement as they lunge upon it.

References

*Beauchamp, Wilbur L., Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 43–70.

Brearley, Harry Chase: "Animal Secrets Told," New York: Frederick A. Stokes Company, 1911, pp. 67–162.

Comstock, Anna Botsford: "The Pet Book," Ithaca, New York: Comstock Publishing Company, 1915, 310 pp.

*Craig, Gerald S., and Agnes Burke: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1933, pp. 176–194.

*——— and SARA E. BALDWIN: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 112–123.
*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 90–94.
*MATHEWS, F. SCHUYLER: "The Book of Birds for Young People," New York: G. P. Putnam's Sons, 1921, 320 pp.
MOSELEY, EDWIN LINCOLN: "Our Wild Animals," New York: D. Appleton-Century Company, Inc., 1927, 310 pp.
NELSON, E. W.: "Wild Animals of North America," Washington, D. C.: The National Geographic Society, 1930, 249 pp.
PALMER, E. L.: "Handbook of Nature-study," Ithaca, New York: The Slingerland Comstock Co., 1928, Part II, pp. 10–77; Part III, pp. 5–69.
*PAYNE, GEORGE E., HENRY H. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book II, Boston: Benjamin H. Sanborn & Company, 1929, pp. 41–58.
*STEPHENSON, MARY BOWEN: "The World of Animals," Chicago: Thomas S. Rockwell Company, 1930, pp. 45–84.
VERRILL, A. HYATT: "Pets for Pleasure and Profit," New York: Charles Scribner's Sons, 1922, 359 pp.

PRESERVING THE BEAUTIES OF AUTUMN

Aims

Enjoyment and appreciation of the beauties of nature leading to planting and conservation of plants.

Awareness of seasonal change.

Suggestions

In the case of plants that retain their colors throughout winter, no method of preserving them is equal to having them growing in the school and home grounds. Each year some colorful plants ought to be started in suitable places close to the building or at the edge of the yard where they will not interfere with the play space. Seedling evergreens a few inches in height can be obtained from the nurseries for as little as 5 cents each. A few sumacs can be transplanted from some wild patch. Seeds of many of the colored plants such as bittersweet, red dogwood, snowberry, and spindle tree can be planted. To prevent them from being trampled during play, plant them in the tree nursery (see the project "Having a Tree Nursery"), and, when large enough, transplant to where they can best be enjoyed.

Many plants become dry and brown, however, and lose much of their beauty in winter. Moreover, it is desirable to bring some of this rich coloration into the schoolroom to enjoy during the winter months.

The leaves of many trees and shrubs make beautiful winter decorations. The leaves would soon fall, and the plants are not injured in any way if the leaves are removed. To keep the leaves from curling, dry them for three days in folded newspapers between large blotters. Place a piece of wide board on top of the stack, and weight it heavily. Change the newspapers daily. Dipping the leaves in melted paraffin or rosin aids in preventing oxidation and thus helps to preserve color, but it is not necessary. Another method of paraffining is to place a small piece of paraffin on each leaf and iron over it with a warm flatiron. The leaves can then be pasted on cardboard or otherwise arranged in an endless variety of patterns and color schemes. Some of the plants with especially colorful leaves are oaks (blended reds,

browns, and greens), red maple (scarlet), sugar maple (shades of orange), silver maples (yellow), birches (yellow), cherries (yellow to red), poplars (yellow), hawthornes (reddish brown), sumacs (brilliant reds), woodbine (red, greens, and browns), variegated dogwood (green, margined with white), red-leaved barberry, and purple-leaved plum.

The flowers of a few plants such as hydrangea and the cultivated everlastings are persistent and make attractive winter bouquets.

A number of plants bear fruits which remain attractive during winter. Snowberry (white), Japanese-barberry (red), rose (pink to red), bittersweet (orange and red), spindle-tree (pink and red), cotoneaster (black, red), privet (black), chokeberry (red, black), mountain-ash (orange to red), high-bush cranberry (red), and Jerusalem-cherry (red) fruits are usually available. The fruits are more attractive on the twigs, which should be cut, not broken, to avoid unnecessary injury to the plant and subsequent infection. A few fruiting twigs can be cut from the plants in such a way as neither to spoil their beauty nor greatly weaken them. The dry fruits of Japanese lantern (*Physalis*) and of honesty (*Lunaria*), singly or combined, make wonderfully attractive winter bouquets.

Many teachers let the children bring in fruits of milkweed, goldenrod, grasses, etc., and paint them. The larger attractive edible fruits such as pumpkins, squashes, apples, and pears will keep for a time in the schoolroom.

The colored twigs of plants are also very attractive, and a few of these may be cut in a careful manner. The red and yellow twigs of some of the dogwoods and willows are especially beautiful. One variety of the box elder has purplish twigs. The twigs of the other variety are green. Wahoo and other species of *Evonymus* are green. Twigs of the buffalo berry and Russian olive are silvery scurfy. Rose twigs are shades of green and red.

Beautiful wreaths can be made of club mosses and, in the south and west, of holly.

It is interesting to try to reproduce the colors of autumn and in this way keep a record of the changing hues. While the leaves are still green, trace one on paper or poster cardboard, and color it with crayons. Color another when the leaves begin to turn and at intervals thereafter until the leaves are brown.

Contributing Learnings

The leaves have been busy making food during the summer. Now they can be gathered without hindering the work of the plant.

We do not entirely understand why the leaves and fruits change color in the fall. Exposure to light increases coloration.

Pressing and drying is a desirable way to preserve plants. Some plants have leathery petals which keep without special care. We call these flowers everlastings.

The colored fruits contain the seeds. We should not take all of the fruit of any plant for decorative purposes. Some should be left to start more plants. In cutting twigs from a plant we should be careful neither to cut it back too severely nor to spoil its shape.

Fall is the most colorful time of the year, but it is possible to enjoy these colors for a longer period. Some things we must keep dry if they are to retain their colors. The nicest way is to plant around our homes and school the evergreens, colored-twigged shrubs, and colored-fruited plants which retain their beauty throughout the winter.

References

*Beauchamp, Wilbur L., Gertrude Crampton, and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 112–120.

Comstock, Anna Botsford: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 734–816.

Pack, Charles Lathrop: "Trees as Good Citizens," Washington, D. C.: The American Tree Association, 1922, pp. 27–41.

*Verrill, Alpheus Hyatt: "The Boy Collector's Handbook," New York: Robert M. McBride & Company, 1927, pp. 48–87.

COOKING A MEAL OUT OF DOORS

Aims

Conservation of forests and wild life through prevention of fires.

Increased satisfaction in outdoor life and cookery.

Suggestions

Plan a type of picnic at which each pupil is to build a small fire and do his or her own cooking. Consult *Cornell Rural School Leaflet*, Vol. 17, No. 2, Camp Fires and Camp Cookery; boy-scout, girl-scout, and campfire handbooks; and any of the other references available.

Let each pupil plan what he will cook, what type of fire he will build, how he will build it, and how he will extinguish it. Try to see that there is a variety of cookery.

Select the most interesting spot within reach where the fire hazard is not too great. If there are boy and girl scouts or campfire girls in the class, let them demonstrate methods of starting fires, kinds of fires, the various types of cooking for which they are suited, and how to put out a fire. Otherwise, invite some of the older members of these organizations to accompany and help. There is a good opportunity for fostering a spirit of service by letting them assist the other pupils, but they must not rob the children of the thrill of carrying out the activity.

A few cautions are in place. Take along a blanket with which to smother the flames in the event that a child's clothing catches fire. This happens so seldom in camp cookery that you need not worry about it, but it is always wise to be prepared, especially when you have responsibility. See that each child selects a safe place to build his fire where it is not likely to spread and where it cannot injure trees. Keep the fires within a small area. Build small fires.

See that all food is well cooked. Let the group discuss their experiences in camp cookery and the purposes and principles of cooking as they gather about the fire later. Discuss fire prevention.

Put all fires out, and test them. Wait a while after extinguishing the fires, and test them again. Do not leave until the coals and ashes are cool.

Contributing Learnings

When wood and other substances burn, the carbon unites with oxygen of the air and forms carbon dioxide gas. We build our fires open rather than compact so that the oxygen of the air can reach all parts. We sometimes fan or blow a fire to bring more oxygen to it and cause it to burn faster.

We need only a small outdoor fire for frying and other quick methods of cookery. There is more danger that large fires will spread if a high wind develops. Moreover, we want a fire that will cook our food without cooking us. There are suitable fires for all forms of camp cookery. It is possible to prepare a good meal over an outdoor fire.

Some materials ignite at lower temperatures and, are therefore, good for starting fires. Dry pine needles, other leaves, fine grasses and weeds, and shreddy bark are such materials. Large, green, and wet materials burn slowly and often hold fire for many days. They are not suitable for a small quick fire which is needed for only a few minutes.

"Fire is a good servant but a bad master." Every year more acres of forest are burned than we have ever planted. With the great number of tourists and picnickers since the coming of the automobile, we have not been able to keep down the fires. A single state has as many as 1000 forest fires in a single year.

People who have camped out very much have almost certainly had the experience of thinking that the fire was out, only to find it springing up again. We should not leave it until there is no feeling of warmth to the hand when placed in the coals and ashes. Even then, we should wait a few minutes and test it again. We can learn to enjoy the out-of-doors and be good citizens of it.

References

*"Handbook for Boys," New York: Boy Scouts of America.

**Cornell Rural School Leaflet*, Vol. 17, No. 2: Camp Fires and Camp Cookery, Ithaca, New York: Cornell University, November, 1923.

*"Girl Scout Handbook," 570 Lexington Avenue, New York: Girl Scouts, Inc.

KEPHART, HORACE: "Camp Cookery," New York: The Macmillan Company, 1928, 143 pp.

DISCOVERING WHAT PEOPLE ARE DOING TO PREPARE FOR WINTER

Aims

Experience contributing to the concept of the necessity for adapting ourselves to the processes of nature.

Interest in the activities about us. Consciousness of seasonal changes.

Suggestions

Begin early to watch people prepare for winter. Let children report their observations each day. In the village and city schools, a field trip to observe the preparations for winter should be made just as the first cold wave approaches. Some likely observations are:

- Hauling and storing coal, wood, and other fuel.
- Putting on storm windows and doors.
- Digging, selling, and storing the winter supply of potatoes and other root crops.
- Picking, selling, and storing apples and other fruits.
- Bringing bulbs and tender plants indoors and protecting others by covering them.
- Saving seeds for planting.
- Providing extra shelter for animals.
- Gathering and storing nuts.
- Canning vegetables, fruits, and meats for winter use.
- Putting on heavier clothing.
- Putting frost shields on automobile windshields and streetcar windows.
- Putting up snow fences.
- Shutting off the water from outdoor drinking fountains, pools, etc.
- Watering plants heavily to help them live through the winter.
- Cleaning and installing furnaces and stoves.

Contributing Learnings

Winter is sure to come. We cannot change nature's ways, but we can learn to know them and get along better.

Crops cannot grow during winter, so we must store part of our fall harvest for food and seed. It is necessary to give trees and shrubs plenty of water in the fall, as they cannot get much moisture in winter when the ground is frozen.

Heat is lost from the body very rapidly on cold days. For this reason we need more clothing, fuel, and well-protected houses.

Farm animals and pets have heavier coats of hair now and do not require homes so warm as ours; but we must give them some protection.

Some plants are able to live through the winter without protection; some need to be covered; still others are very tender and die as winter comes on.

Snow fences are used to keep the wind from piling snowdrifts on the roads and blocking them.

Winter is a hard time for plants and for people and other animals in cold regions. It is important that we prepare for it.

Winter will also bring many joys. Many people will not be so busy then. The evenings will be longer, and we can look forward to enjoying our fruits, nuts, and other products in warm homes by cheery fires. We shall soon become accustomed to cold weather and be ready for winter sports.

References

*ALDER, GRACE: "The Seasons," Columbus: American Education Press, 1935, 36 pp.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 16–38.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 10–16.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 27–37.

DISCOVERING WHAT ANIMALS DO AS WINTER APPROACHES

Aims

Experiences contributing to the concept of the great influences of seasonal climatic changes on living things and of survival by adjustment.

Interest in animal life and its problems.

Suggestions

While the difficulty involved in observing the disappearance of many animals at this time of year presents a considerable problem, a limited number of observations such as the following will be feasible in most schools.

Watch the squirrels storing the harvest of nuts and acorns in their homes in hollow trees.

Note the gradual disappearance of some of the familiar birds.

Report the insects crawling into the homes and school building to hibernate. Look in trash piles for other hibernating insects. Spade over a small area in the garden, flower beds, or other well-drained areas, and examine the soil for insects and earthworms. If no earthworms are seen, dig deeper until you encounter them.

While the leaves are still green, select a plant infested with insect larvae. By observing them daily, try to discover what becomes of the insects.

Observe the flocks of the common milkweed or monarch butterflies gathered in preparation for their flight southward.

Note the heavy shaggy appearance of the hairy coats of horses, cattle, sheep, and dogs at this time of year.

If possible, note when frogs and toads disappear.

Try to find snake holes in the ground where these animals are in winter quarters.

A trip to any lake or stream very late in the fall will usually show the shallow waters, which teemed with life, now almost deserted. The fishes, frogs, insects, and other forms have, for the most part, moved to deeper water.

Make a list of the animals that seem to continue active as winter approaches.

Contributing Learnings

Some animals, such as squirrels, store food when it is abundant in the fall. Others eat heavily and become fat. They then retire into the more protected places and become inactive during the cold period. Many hibernate in the ground. Still others migrate southward where food is more abundant. Only animals that keep a constant high temperature remain active here during the winter. They are called warm-blooded animals. Only birds and hairy animals are warm blooded. Other animals can be active only in warm weather.

Fur-bearing animals grow heavier coats at this season. A few such as the weasel and the snowshoe rabbit change color, becoming white, and are not easily seen against the snow.

Most of the water animals leave the shallow water where they have fed during the summer, moving into deeper water where the temperature is more constant and there is no freezing.

Winter is a hard time for many animals. It is cold, and food is hard to obtain, especially during snowy periods.

Climate controls the lives of animals to a large extent. Nature is neither friendly nor unfriendly. The seasons come surely. Winter destroys many living things. Most animals are not cared for in any way, and only those live over which have some way of getting along when conditions become unfavorable.

References

*Alder, Grace: "The Seasons," Columbus: American Education Press, 1935, 36 pp.

*Athey, Lillian Cox: "Along Nature's Trails," New York: American Book Company, 1936, pp. 65–102.

*Beauchamp, Wilbur L., Gertrude Crampton, and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 80–85.

*Cornell Rural School Leaflets, Vol. 27, No. 2: Fields in Fall, Ithaca, New York: Cornell University, November, 1933.

*Craig, Gerald S., and Sara E. Baldwin: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 39–69.

*——— and ———: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 103–111.

*——— and Margaret G. Condry: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 3–9, 19–81.

Cram, William Everett: "More Little Beasts of Field and Wood," Boston: Small, Maynard and Company, 1912, 303 pp.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book III: "In Field and Forest," New York: Row, Peterson & Company, 1928, pp. 7–21, 63–84, 95–96.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown and Company, 1931, pp. 59–68.

*GORDON, EVA L., and JENNIE HALL: "Nature Stories for Children—An Autumn Book," New York: Mentzer, Bush & Company, 1926, pp. 59–88.

MOSELEY, EDWIN LINCOLN: "Our Wild Animals," New York: D. Appleton-Century Company, Inc., 1927, 310 pp.

NELSON, E. W.: "Wild Animals of North America," Washington, D. C.: The National Geographic Society, 1930, 249 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 53–67.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 49–60, 69–76, 99–109.

*PAYNE, GEORGE E., HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book I, Boston: Benjamin H. Sanborn & Company, 1929, pp. 1–20.

*PERSING, ELLIS C., and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 7–16.

COLLECTING INSECT PUPAE

Aims

An avenue of interest and enjoyment.

Experience contributing to the understanding of metamorphosis, the controlling influence of environment, and the problems of survival.

Suggestions

Insects spend the winter in various stages. A great many pupate in the fall, emerging as adults in the spring. The best time to collect pupae for this thrilling, colorful spring event is in the fall after the leaves have fallen when they can be readily discovered.

Search for the cocoons of the moths and other pupae on the branches of trees and shrubs, beneath loose bark of tree trunks, in hollow trees, beneath projecting ledges of buildings, and on objects of all sorts that might afford attachment and a measure of protection. Be sure to include willow, apple, hawthorne, and poplar for the cocoons of the beautiful large Cecropia moth which is common in most localities. Keep all cocoons, however, for beautiful moths will emerge from many of the smaller ones.

Spade over the soil in a garden to collect the species of moths, butterflies, and beetles that pupate in the ground. Choose light soil, and dig deep. A sandy bank is also an excellent collecting place.

See the suggestions for the project "Rearing Insect Larvae" for directions for obtaining pupae in this manner.

Examine each pupa by gently pressing and shaking it to discover whether or not it contains a live pupa. A hole in a cocoon means that a hungry bird found the pupa first and devoured it.

The method of storing pupae is important. Some teachers report that the insects fail to emerge in the spring. To prevent this it is well to keep the pupae in a cool place where they will not dry out. An unheated hall or room is best. An outer window ledge is a good place. If they must be kept in the schoolroom, place them near a window close to the floor. Many teachers have good success placing cocoons over moist earth in

open jars. The soil should be moistened occasionally. Some lay them on the soil in a vivarium. The pupae found underground should be buried in the moist soil of the containers.

An occasional adult will emerge during the winter if the pupae are kept indoors, but most of them will appear early in the spring. Suggestions will be found in the spring program for further activities to be carried on at the time of their emergence.

Contributing Learnings

When larvae are full grown, they give out a liquid which hardens into a protecting cell or pupa case. Some of the moth larvae first spin silk which will form a covering for the pupa case. The silk can be unwound and woven into silk cloth.

Most insects pupate in rather protected places, many of them in the ground. It is important that they choose well-hidden places in which to pupate and not too wet, as they cannot move about to hunt new locations during the pupa stage.

The pupae are alive, although they do not move about. They are very busy rebuilding themselves into moths, butterflies, beetles, and other adult forms.

Birds peck holes in many of the pupa cases and devour the insects.

Many of the butterflies and moths spend the winter in the pupa stage. In spring we shall see the beautiful adults emerge. Each kind of insect builds a different type of pupal cell. When spring comes it will be very interesting to discover what kind of insect will emerge from each.

Moths, butterflies, beetles, flies, bees, wasps, ants, and certain other insects develop through the egg, larval, pupal, and adult stages. Other animals, too, go through many changes as they develop, but they usuallv do not have a quiet pupa stage. Instead, they continue to move about while they are changing.

References

Comstock, Anna Botsford: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 308–457.

Comstock, John: "An Introduction to Entomology," Ithaca, New York: Comstock Publishing Company, 1930, pp. 185–191, 464–545, 571–772.

Eliot, Ida Mitchell, and Caroline Gray Soule: "Caterpillars and Their Moths," New York: D. Appleton-Century Company, Inc., 1902, pp. 42–55.

Hodge, Clifton F.: "Nature Study and Life," Boston: Ginn and Company, 1902, pp. 260–273.

*JOHNS, LINA M., and MAY AVERILL: "Moths and Butterflies," Dansville, New York: F. A. Owen Publishing Company, 1930, 127 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book I: "Hunting," New York: The Macmillan Company, 1932, pp. 92–99.

WEED, CLARENCE M.: "Insect Ways," New York: D. Appleton-Century Company, Inc., 1930, pp. 282–296.

STOCKING THE AQUARIUMS

Aims

New avenues of enjoyment and interest.

Experience contributing to concepts of the dependence of living things upon the environment and of the balance of life.

Suggestions

Although aquariums are rather expensive, it is often better to purchase than to try to construct them. The expense need not deter any teacher, however, for small containers can be obtained at little cost. Moreover, small aquariums possess certain advantages over a single large aquarium. They are easily moved about for observation. They make it possible to keep many kinds of animals that would devour one another if placed together in one large aquarium. They lend themselves better to small group and individual project work. They afford more points of interest in the room and are easily cleaned and changed. If it is possible to purchase a large aquarium in addition, it can be kept with less change and will accommodate larger forms; but the small aquariums should come first.

Rectangular aquariums are preferable to round ones, in that there is less refraction to cause the contents to appear distorted; but small round bowls are reasonably satisfactory and can be obtained for as little as 25 cents. Homes and stores will often contribute suitable small containers. Rectangular aquariums of two-gallon capacity are almost ideal. Satisfactory ones with metal bottoms can sometimes be obtained for as little as $2 each, while the better ones with glass bottoms cost considerably more. Broken windshield glass for constructing aquariums can be obtained very cheaply. The cementing can be done at school, but it is important to have a good workman construct a strong frame to hold the heavy glass.

Place a small amount of rich soil in the bottom of each aquarium, piling it higher at one end. Cover the soil with plenty of clean sand. The soil can be omitted, but it furnishes materials for more vigorous plant growth. If clean, sharp sand is not easily obtainable, wash some in another vessel by stirring it in water and decanting several times. Water for the aquarium

may be obtained from the pond. Tap water is satisfactory, although it is well to let it stand for a day to allow it to aerate and most of the chlorine to escape before using it. Fill the aquariums without exposing the soil and roiling the water.

The aquariums are now ready to stock. Some teachers, who keep only a few goldfish, fail to take advantage of the opportunities for interesting activities that this project affords. If there is a pond within reach, it should be visited by the class. Stream animals are adapted to well-aerated water and do not, as a rule, thrive in the aquarium, unless it is equipped to provide constant change of water. Pond animals accustomed to stagnant water are better suited to live in aquariums.

Borrow a pair of wading boots. You will also need a dip net, which ought to be a part of the science equipment of every school. Such a net can be purchased, but it is quite expensive. It can be constructed readily with the help of the janitor or the older pupils at a cost of less than a dollar. Bend band iron into the desired shape and bolt to a strong wooden handle. Make a shallow net of canvas and strong netting. Shallow strainer pans can be used for collecting some water animals.

If possible, induce two older boys to accompany the class and seine with a minnow net. The minnow net will catch the larger free-swimming animals. With the dip net drag in some of the marginal vegetation and some of the ooze from the bottom of the pond. Spread this material out on the ground, and collect the animals as they crawl out of the mass.

Place the animals in buckets or minnow pails with a little water. Collect plenty of submerged water plants, such as algae, milfoil, and Canadian waterweed. Include a few floating plants such as duckweeds. Dig up a few small specimens of arrowhead, sedge, rush, cattail, or other partly submerged plants from some spot where they are abundant.

Keep all of the plants and animals in water until you can place them in the aquariums, which should be ready before making the trip. The arrangement of the aquariums permits of endless variation, but certain general procedures are important. Root the plants which grew rooted in the soil of the pond. This is easily done by thrusting the tip of the forefinger and the end of the stem through the layer of sand. Set the partly submerged plants at the shallow end of the aquarium and the submerged ones in the deeper portion. Avoid too many plants. There

should be areas of open water. Drop in a small mass of algal threads weighted with a stone. Add a few duckweeds, if preferred. Introduce a few small animals, but do not overload the aquarium, or there will be insufficient oxygen. Do not try to put all kinds of animals in each aquarium unless you wish them to prey upon one another. Rather let each group of children select one or more animals for their aquarium. The remaining plants and animals may be placed in one large aquarium, a candy bucket, tub, or other container.

The aquariums will provide opportunities for an almost unlimited amount of spontaneous undirected observation and enjoyment. In addition, they may be used in many planned activities. For example, some teachers utilize one aquarium for growing guppies or other tropical minnows which serve to introduce the general concept of reproduction and the birth of living young.

Contributing Learnings

Many animals and plants live partly or altogether in water. An aquarium is really a small pond arranged so that we can observe the plants and animals. We try to make the conditions in our aquarium much like those in the pond where we obtained the plants and animals.

Living things must have air. Water contains some air. As long as the animals have plenty of air they occupy various parts of the aquarium. When air is insufficient, they swim near the surface. When they do not have air, they die. Therefore, we must not put too many animals in an aquarium. Sometimes the plants are covered with bubbles of "air" (oxygen) which they have given off. Some animals such as turtles have to come to the surface for air every little while, as we do when we dive. Some water insects carry air bubbles with them enmeshed in the hairs on the body. Frogs can breathe through their skins. Fishes do not have to come to the surface for air, as they have gills for taking in the air in the water. They open their mouths at regular intervals, gulp some water, and force it out over the gills which absorb the oxygen.

Some animals eat the water plants. Others eat dead material of various sorts. Many of the larger animals eat the smaller ones; and some smaller forms, such as dragon-fly larvae and leeches, prey upon the larger animals. Animals spend most of

their time getting food. It is not necessary to feed the plants, as they make their own food. In fact, plants make all of the world's food.

Animals are very much affected by their surroundings. Some animals seek the darker shaded places in the ponds. They do not do well in the aquarium if it is placed in too bright a light. Most of the animals can stand rather low temperatures but are more sluggish in cold water. They are easily killed if the water becomes too warm. (Warm water can hold very little oxygen.)

Animals have very interesting ways of moving about in the aquarium. Snails and clams thrust out a fleshy foot and drag the body forward. Fishes swim largely with their tails, using their fins for balancing. Water insects, turtles, and frogs use legs as oars.

The other habits of these water animals are equally interesting. Any boy or girl can have an aquarium and learn to know the water plants and animals better.

References

*Bianco, Margery W.: "All about Pets," New York: The Macmillan Company, 1930, pp. 110–119.

Cornell Rural School Leaflet, Vol. 21, No. 1: Teachers' Number, Ithaca, N. Y.: Cornell University, September, 1924.

*Craig, Gerald S., and Agnes Burke: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 33–41.

Crandall, Lee S.: "Pets and How to Care for Them," New York: New York Zoological Park, 1921, pp. 261–296.

Eifrig, C. W. G.: "Our Great Outdoors—Reptiles, Amphibians, and Fishes," Chicago: Rand-McNally and Company, 1930, pp. 223–232.

*Fisher, Clyde, and Marion L. Langham: "Nature Science," Book I: "World of Nature," New York: Laurel Book Company, 1934, pp. 95–99.

*Herring, Mary Belle: "The Story of Frogs," Columbus: American Education Press, 1935, 36 pp.

Hodge, Clifton F.: "Nature Study and Life," Boston: Ginn and Company, 1902, pp. 393–403.

*Hyman, Mary Watson and others: "The Find Out Book," Vol. I, Chapel Hill, North Carolina: University of North Carolina Press, 1934, pp. 74–80.

Innes, William T.: "The Modern Aquarium," Philadelphia: Innes & Sons, 1931, 62 pp.

Mellen, Ida: "The Young Folks' Book of Fishes," New York: Dodd, Mead & Company, Inc., 1927, pp. 66–73.

Morgan, Ann Haven: "Field Book of Ponds and Streams," New York: G. P. Putnam's Sons, 1930, pp. 26–45.

*PATTERSON, ALICE JEAN: "Nature Study and Health Education for Sixth Year," Normal, Illinois: McKnight and McKnight, 1927, pp. 189–211.

SCHMUCKER, SAMUEL CHRISTIAN: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 72–79, 136–146.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 84–96.

SETTING UP TERRARIUMS

Aims

New avenues of interest and enjoyment.

Experience contributing to the concept of the dependence of living things on the environment.

Suggestions

Terrariums are as interesting as aquariums and permit of even greater variation. One terrarium may house a small section of the forest floor; another, a miniature swamp; etc. Combination terrariums and aquariums may be arranged. The ideal way is to visit an area and try to reproduce some of its interesting features.

Ordinary aquariums make satisfactory containers to use for terrariums, though any glass receptacle large enough to hold a few plants will do. The purchased terrariums usually have a slanting front, which adds to the view, but this is not essential.

Place a band of moss on edge around the base of the terrarium with the green side next to the glass. Cover the bottom with sand. A few pieces of charcoal are then scattered over the sand for adsorbents. This is covered with about two inches of loam soil, the surface being varied as desired. Adding leaf mold, peat, and sand will make any available soil light enough to use for this purpose. Arrange a few lichen-covered rocks, a rock ledge, or any other formations desired. Then set out the ferns or flowering plants to be used. Nearly cover the remaining exposed areas of soil with clumps of mosses and liverworts. Lay a small branch or piece of fallen tree bearing attractive fungi in a natural position. Water the plants and soil well.

Cover the terrarium with a piece of glass, leaving a very narrow opening. Find by trial the size of opening that will retain enough moisture to keep the plants fresh yet will not maintain such high humidity that fungi will develop. Place the terrarium in a position where sun does not fall directly upon it during the heat of the day, as the covered container would retain sufficient heat to injure the plants.

The terrarium needs only occasional watering, as the water given off by the plants condenses and is used again by them.

Such a moist habitat is favorable for luxuriant growth, but there is a tendency for soft plants to mildew. Use plants with tough leaves, and do not overcrowd the terrarium. It will also be much more beautiful with abundant open spaces.

If possible, select the plants in keeping with the terrarium. For example, use plants that commonly grow in the woods, such as wintergreens, hepaticas, white sweet violet, bunchberry, twinflower, two-leaved Solomon's seal, wild lily of the valley, mosses, ferns, and liverworts, if you are arranging a terrarium of this type. In a swamp terrarium use swamp plants such as swamp saxifrage, low-bush cranberry, Pyrola, cotton grass, pitcher plants, and swamp mosses. Some rock exposure will furnish a few rock plants for a rock-garden terrarium—such plants as Houstonia, Heuchera, pale corydalis, Oxalis, rock cress (*Arabis*), the rusty woodsia fern, mosses, and liverworts. It is not necessary to find any of the plants listed above. They are merely suggestive. Part of the joy will come in trying out the plants common in the region. If it is not feasible to collect wild plants, garden and greenhouse plants such as wandering Jew, ivy, lily of the valley, African violet, Begonia, Santolina, and Sedum can be used to make very beautiful terrariums.

Only small animals are suitable for the ordinary terrarium. Flies and many other insects can be reared in the higher, drier portion. Lizards, salamanders, and the smaller toads and frogs can be kept if there is a small pool of water in one portion. A good way to arrange such a pool is to sink an inconspicuous water-tight container in one part of the terrarium. One method is to fit a narrow piece of glass across the terrarium at the bottom in such a way as to divide it into a drier and wetter portion. The glass separator is not in evidence, being covered with soil and vegetation.

It is essential not to overload a terrarium with animals. They soon make the plants unattractive, and there is not sufficient food. Choose the animals with reference to the habitat that you are trying to reproduce. Read about the habits of these animals, and try to provide for their needs. It is especially important to provide them with their accustomed food.

Contributing Learnings

Plants must have water. They take up the water from the ground and give off some of it through their leaves. In our

terrarium this water collects on the glass. If the air is too dry, as in most of our houses, the plants lose too much water in this way and finally die. The air in our terrarium is moist, and we can have beautiful winter gardens.

The moist air is also favorable for the robber plants (fungi), which live on our green plants and get their food from them. Mildew and other parasites in this way kill a few of the green plants that we try to grow in terrariums.

The green plants also need light in order to grow. Some of them grew in the shaded woods, so it is not necessary to place the terrarium in full sunlight. Plants also need soil and air. Even the roots of the plants need air, so we use light loose soil which will let air through to the roots.

The animals must have food. There would not be enough food in our terrarium for a large animal. Some animals eat plants, while many live on animal food. Lizards, frogs, toads, and salamanders eat the insects.

Frogs, toads, and salamanders absorb the water through their skins. To get a drink they must be in water. Some animals get enough water in the juicy food that they eat.

Not all plants and animals need the same environment. Each kind of living thing thrives best in a certain type of environment. If the environment is not suitable for it, or is too well suited to its enemies, it cannot succeed.

References

*Bianco, Margery W.: "All about Pets," New York: The Macmillan Company, 1930, pp. 119–134.

*Comstock, Anna Botsford: "The Pet Book," Ithaca, New York: The Comstock Publishing Company, 1915, pp. 295–300.

Cornell Rural School Leaflet, Vol. 23, No. 1: Teachers' Number, Ithaca, N. Y.: Cornell University, September, 1929.

Eifrig, C. W. G.: "Our Great Outdoors—Reptiles, Amphibians, and Fishes," Chicago: Rand-McNally & Company, 1930, pp. 232–234.

*Greenwood, Thelma: "Indoor Gardens," Columbus: American Education Press, 1935, 36 pp.

*Mann, Paul B., and George T. Hastings: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 342–343.

*Smith, Jeanette: "Pets at School," Columbus: American Education Press, 1934, 24 pp.

EXAMINING THE PLANTS AS WINTER APPROACHES

Aims

Experience contributing to concepts of the dependence of living things on the environment and of survival by adjustment.

Interest in annuals and perennials.

Suggestions

It is well to begin examining the plants by the time that killing frosts occur and most of the leaves have fallen. Visit the trees, shrubs, flower beds, parks, woods, streams, and fields with which the children have been familiar during spring, summer, and early fall.

Note that the leaves have now fallen from all of the trees, except the evergreens. Try to guess why the tree is unable to keep them through the winter. Examine the trees to discover whether the buds are present to form next year's leaves and flowers. See whether the seeds have already fallen and scattered to start new trees.

Examine the shrubs. Note that while some of the old stems are dead, new ones have grown up in many cases and bear buds for next year's flower display. A few shrubs such as Hills of Snow, Anthony Waterer's Spiraea, and Cinquefoil die back to the ground. Look near the surface of the ground for the buds from which they will send up new flowering stems in the spring.

Make a list of plants that are still green. These are likely to remain wintergreen. Examine them to try to discover how they are able to continue green. Notice that they generally have thick tough leaves which lie close to the ground, two characteristics that prevent water loss and thus enable them to retain their leaves in winter when water is difficult to obtain.

Examine the dry tops of some of the great array of plants which are apparently dead. Look for the seeds which will carry the life until spring. Plant a few of these seeds in a box of dirt in the schoolroom to see whether they are alive.

Notice that some of the plants with dead tops are alive underground. Try to explain why it is easier for the part below ground to live over winter than for the top to do so. Observe beds of

perennials, noting how they are protected by the old stalks, fallen leaves, and trash.

List some of the plants found ready to pass the winter in each of the following ways:

1. Entire plant alive and green.
2. Alive, but leaves have fallen.
3. Alive only below ground.
4. Only seeds still alive.

Let children write to friends or relatives living far to the north or south of your region, asking the condition of plants at the time and which plants remain green there during winter.

Contributing Learnings

Most plants show changes in the fall, although we do not know all about why they do so. We do not believe that they plan for winter as we do, but the changing season in some way causes them to make changes that enable them to live. Drying winds, sleet, and cold will come, as they have done each winter, and only the plants that are in condition to stand the trials of nature will live.

The evergreens (pines, firs, spruces, cedars, etc.) have small, tough leaves and generally are able to live through the winter in leaf. Many of their seeds are scattered in the fall. A few other plants with tough dry leaves (wintergreens, Mahonia, low-bush cranberry, etc.) keep their leaves throughout winter. The leaves of some plants, such as evening primrose and dandelion, form a rosette against the ground where they are usually well protected by fallen leaves and by snow.

The other trees and shrubs usually drop their broad leaves and, therefore, cannot make food during the winter. These plants could not get enough water from the cold ground to supply such big leaves. However, the buds are already present to start next year's leaves and flowers. In fact, they have been waiting here since they were formed in the spring.

Many plants die back at the tops, but the underground parts are able to live through the winter. Bluegrass, hollyhocks, tansy, some wild sunflowers, asters, goldenrods, and many other plants pass the winter in this way. The underground parts escape drying winds and frequent temperature changes.

A very large number of plants die below as well as above ground. Only the baby plants in the seeds live through the winter. In the

extreme climates most of the plants can survive the winter only as seeds. In the south, where the winters are mild, many of the plants can secure enough water to enable them to remain green throughout the year.

References

*ALDER, GRACE: "The Seasons," Columbus: American Education Press, 1935, 36 pp.

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 122–123.

* ——, HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book III, Chicago: Scott, Foresman & Company, 1936, pp. 131–139.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 83–94.

*GORDON, EVA L., and JENNIE HALL: "Nature Stories for Children—An Autumn Book," New York: Mentzer, Bush & Company, 1926, pp. 19–43.

*HYLANDER, CLARENCE J.: "The Year Round," New York: G. P. Putnam's Sons, 1932, pp. 173–204.

METZGER, OLIVER PERRY: "Nature Rambles—Autumn," New York: Frederick Warne & Company, 1932, 160 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 111–121.

STARTING THE BULBS FOR A WINTER FLOWER GARDEN

Aims

Interest and satisfaction which lead to a desire to grow plants.

Useful knowledge of methods of growing flowers for the home in winter.

Experiences contributing to the concept of the dependence of living things on their environment.

Suggestions

The educational value of this activity warrants purchasing bulbs and containers out of regular school funds. If this cannot be arranged, it is entirely practicable to sell enough of the plants as they come into bloom to pay all costs. The plants may be grown as either group or individual projects.

Decide what kinds you wish to grow, and purchase large, firm bulbs. Before the ground has frozen, fill a box with light loam soil and another with sand and pebbles, so that you will have plenty of these materials on hand. The flowerpots and glass or crockery dishes can be purchased or picked up as needed. Discarded pans make good containers.

A great many kinds of bulbs can be brought to flowering in the schoolroom. The following are among the most satisfactory.

Colchicum.—The easiest to grow. Simply place the corm in any shallow vessel, or merely lay it on the window sill. It will flower almost anywhere, but the blossoms are a richer rose color if grown where they receive plenty of light. Remove the flowers as they fade and drop, and others will follow. Colchicums are not widely advertised but are available from several nurseries.

Narcissus.—Paper White, Golden Sun, and Chinese Lily varieties do well in water and pebbles. Fill in an inch or so of sand and gravel. Set three or more bulbs on the sand, and fill in enough pebbles to hold them in place. Keep in a cool dry cellar, spare room, or dark closet until the roots are well developed and top growth begins. Then bring them into the schoolroom to flower. Keep the water about even with the bottom of the bulbs. Narcissus does better if not started until November.

The large trumpet varieties of narcissus, often called daffodils, can also be grown satisfactorily in the schoolroom and may be had in yellow, white, and red. The cluster-flowered daffodils are also suitable. Plant three or four bulbs during September or October in rich sandy loam in a five- or six-inch flowerpot, setting them well below the surface of the soil. Place the flowerpots in a cool dark place. Water occasionally. Bring them into the classroom after top growth begins, and give them plenty of water.

Tulip.—Most single flowering species of tulips do well indoors. Start them any time from September to December. Set about half a dozen bulbs in each flowerpot or pan, so that they are just beneath the surface of the soil. Start them in a cool dark place, and care for them as described for the larger varieties of narcissus.

Hyacinth.—Be sure to get large bulbs. Start them any time from September to December, and grow them in the same manner as tulips. Three bulbs in each container make a nice showing. Hyacinths can also be grown in glasses of water. Put a piece of charcoal in each container. Keep in a cool place until the water is filled with a mass of root growth. Roman hyacinths are especially suitable for growing in water and pebbles.

Amaryllis.—Plant one large bulb in each container. Cover with soil only to the shoulder, and pack firmly. Keep in a fairly cool place, and water sparingly until growth starts. Bulbs of the moderate-sized Belladonna Major variety are relatively inexpensive. Plant about November.

Anemone.—The poppy-flowered anemone is easily grown indoors. Plant three or four roots in a five- or six-inch flowerpot during October or November, using rich, porous soil. Keep in a cool place, and give very little water until the plants are well started. Then bring them into the schoolroom to flower.

Freesia.—Grow in the same manner as tulips. Place them near a window where they will not be too warm.

Lily of the Valley.—Place a bundle of about twenty-five pips in a flowerpot, filling in about them with light soil. Allow the points of the pips to project out of the soil about an inch. Place the flowerpots out of doors, bringing them into the schoolroom when you wish the pips to flower. Keep in a

shaded place until the spikes are three to four inches high. Then place them where you can enjoy them most.

Crocus.—Grow as you would tulips, setting several of the small bulbs at a shallow depth in each container.

Muscari or Grape Hyacinth.—Grow as you would tulips, planting four to six bulbs in a five-inch pot.

The blossoming will come during the period of your winter science activities. See the suggestions for the winter project "Holding a Winter Flower Show" for further directions for getting educational satisfactions from the flowers and for renewing the bulbs for another year.

Contributing Learnings

Some plants store food in bulbs, roots, or corms. A bulb is a fleshy bud or growing point. A corm is a bulblike fleshy stem.

When the bulbs, roots, and corms are given moisture and kept where it is not too cold, they begin to grow into plants.

The first part of the new plant to grow is the root system, which will support the shoot and bring it water. Roots will grow well at lower temperatures than leaves. By starting our plants in a cool place, we keep the tops back until a strong root system is formed.

We choose large fleshy bulbs which contain enough stored food to start the growth in the dark where the plant cannot make food.

When the shoots begin to grow, we bring them into a warmer room to hasten top growth. The shoots are pale when we bring them out to the light, as plants must have light to become green. As soon as the leaves become green, they make food. The plants thus have two sources of food, plenty of moisture, and warmth. They grow very rapidly under these conditions and are ready to flower much sooner than plants started from seeds.

Plants differ as do animals, and we have to learn to care for the different kinds. Growing plants is one of our greatest joys in life. It is also possible to earn extra money growing plants. The truck gardeners and florists earn their living in this way, and it is an important part of life on the farm.

For a further statement of learnings, see the suggestions for the project "Holding a Winter Flower Show," in the winter outline.

References

Comstock, Anna Botsford: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 596–606.

*_Cornell Rural School Leaflet_, Vol. 20, No. 3: House Plants, Ithaca, New York: Cornell University, January, 1927.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-Doors," Boston: Ginn and Company, 1932, pp. 73–77, 86–89.

"Dreer's Hints on the Growing of Bulbs," Philadelphia: Henry A. Dreer, 1914, 79 pp

*FISHER CLYDE, and MARION L. LANGHAM: "Nature Science," Book II: "World of Nature," New York: Laurel Book Company, 1934, pp. 92–94.

*——— and ———: "Nature Science," Book IV: "In Field and Garden," New York: Laurel Book Company, 1934, pp. 70–75.

MEIR, W. H. D.: "School and Home Gardens," Boston: Ginn and Company, 1913, pp. 5–19.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book V. New York: Silver, Burdett & Company, 1935, pp. 34–38.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 89–93.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 11–17.

MAKING A COLLECTION OF STONES WHICH TELL A STORY OF THE PAST

Aims

Enlargement of the child's concept of time. Contribution to the concept that variations in the energy received from the sun have profound effects on the earth and to the further concept that natural forces bring about continual evolution of the earth and the conditions for existence.

A leisure-time interest in collecting and observing rocks.

Suggestions

Many children collect stones without the inspiration of a teacher, and a suggestion to make a collection usually meets with a spirited response. Teachers who have not directed such an activity have a surprise in store, as the number of stones brought to school will truly amaze them.

Let the children bring any stones that interest them. Fragments about the size of the palm of the hand make good specimens, being large enough to show variations in structure yet not so large as to be cumbersome; but any size will do.

Rock outcrops, gravel pits, stream beds and shores, road and railroad cuts, and cultivated fields are all good collecting places. Small stones can be found in almost any school community in city or country, especially throughout the glaciated area.

The principal difficulty lies in identifying the stones. Each school ought to own reference collections of some of the commoner things in nature properly labeled, as part of the regular school equipment. Lacking such a named collection of stones, teacher and pupils will be able to identify most of the stones with these suggestions and the help of a good book. Simple characteristics which help in recognizing some of the commoner ones are:

Sandstone.—Rough, sandy; wears away on rubbing with hard objects.

Limestone.—Effervesces if dilute acid is dropped on it.

Marble.—Limestone changed to a light-colored, fine-grained rock; effervesces with acid.

Shale.—In layers; softer than slate; will often write on objects; various colors.

Slate.—Usually in thinner layers than shale, harder; does not write; various colors.

Conglomerate.—Various types of rock cemented together.

Quartz.—Very hard, scratches glass; usually opalescent to clear, white, pink, purple, yellowish, or brown.

Quartzite.—Like a fine-grained sandstone but very much harder and more compact.

Granite.—Quartz crystals firmly fused with other crystals of feldspar and hornblende (red, gray, black, or green) and shiny flakes of mica. Very hard.

Gneiss.—Layers of granite or of gravel fused together, usually giving a banded appearance.

Schist.—Bluish gray to greenish, often soapy feeling, foliated.

Basalt.—Dark, not shiny, fine-grained, hard.

Obsidian.—Black, glassy, with curved fracture.

Tufa.—Porous, light, effervesces with acid.

It would not be essential to name the stones in order to gain an elementary idea of the past, but children are seldom satisfied without the names. It is more important to note that some of the stones are very hard, having been formed under great heat and pressure, while others are softer and occur in layers formed from sediment in water. Still others show the effect of some heat and pressure. Look for the shells of tiny animals in the coarser limestones.

Note the shape of the stones in the collection, comparing them with the fragments of rock about any exposed rock surface. Try to wear away the sharp edges of the rock fragment to resemble the rounded stones. Discuss how and when these stones were worn to their present shape.

Examine some sandy soil. Look at the tiny particles of sand with a lens. Account for the origin of sand.

During the progress of the project, encourage the children to read simple accounts of the origin of the rocks, of deposition, fusion and change with heat and pressure, erosion, glaciation, and the present uses of the commoner stones.

Children like to make individual collections. Let them select their best specimens of each of the common rocks, together with some that show glacial and stream action and other phases of the story of the past. In most localities some fossils will be found or contributed for the collection. Let the children label each stone neatly with a very small piece of gum paper and place each

specimen in a small cardboard box. Fit the small boxes into a shallow tray made from a larger wooden box or carton.

Encourage children to write "The Story My Rock Collection Tells."

Contributing Learnings

Everywhere over the earth, rock is either exposed at the surface or lies below the loose soil and debris. Melted rock pours from volcanoes deep in the earth. We conclude that the earth is of rock. Most of this rock is not in layers and shows by its form that it was once very hot. Such rocks are granite, quartz, and basalt. They are known as igneous rock. Geologists who study the rocks conclude that the earth is very old, probably hundreds of millions of years.

Igneous rock gradually weathers away, forming rock waste, gravel, sand, soil, and minerals in solution in the water. As a rule, each soil particle has a rock center. The rock waste settles in the bottoms of oceans, lakes, and streams as sediment and becomes cemented together to form sedimentary rocks. These rocks are usually in layers and can be seen along the bluffs of many valleys. They are also found on the high hills and mountains, showing that these were once under water and have since been heaved upward as the earth cooled and wrinkled or as movements deep in the earth caused changes in the surface. Shale is a sedimentary rock formed largely of clay. Sandstone consists of sand grains (largely quartz) cemented together. Conglomerate, as the name suggests, is made up of various materials. Some limestones are largely shells of animals cemented together.

By long action of water, by heat, and by pressure, sedimentary and igneous rock materials are sometimes fused very firmly to form altered (metamorphic) rocks such as gneiss, which consists of gravel or of pieces of granite fused together, and quartzite, which is sandstone altered by addition of more quartz about each sand grain.

The outcrops of rock in any locality were formed in approximately their present location, although they may have been extruded from deep in the earth, and tell the story of the past of the region. The boulders, cobblestones, and sand may have come from a long distance. In the north-central part of the country most of this material was brought in by the great ice

sheets which came down from the North. The rocks were ground smooth by the action of ice, water, and other stones. Many of them were rolled along down the streams.

We can hardly realize that huge ice sheets or glaciers once covered the country where we now live, but the ice even now never entirely melts in the far North, and it is estimated that lowering the average temperature four degrees over a period of time would bring a return of the glaciers. We are very dependent upon the sun. If it furnished us a little less heat for a time, great changes would come over the earth.

Some of the rocks contain either remains or imprints of plants and animals. They furnish much of our knowledge of the life in the long-past ages.

While the large continental glaciers occurred many thousands of years ago, they are comparatively recent in the history of our very old earth. They have left a region with a young surface, young soils, and young valleys.

Since the earth is so very old, it is reasonable to expect that it will continue for a longer time than any of us can comprehend. Yet the earth, although old, is probably one of the later developments in the vast universe.

Rocks have many uses today. We use them for buildings, roads, fences, furniture, ornaments, and many other purposes. Petrified wood is stone that has so gradually replaced the particles of wood that the apparent structure of the latter is maintained.

References

*_Cornell Rural School Leaflet_, Vol. 19, No. 3: Rock Stories, Ithaca, N. Y. Cornell University, January, 1926.

Cornell Rural School Leaflet, Vol. 21, No. 1: Teachers' Number, Ithaca, N. Y.: Cornell University, September, 1927.

*_Cornell Rural School Leaflet_, Vol. 21, No. 3: Rock and Minerals, Ithaca, N. Y.: Cornell University, January, 1928.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 174–179, 186–188.

*FISHER, CLYDE, and MARION L. LANGHAM: "Nature Science," Book III: "Our Wonder World," New York: Laurel Book Company, 1934, pp. 80–92.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush and Company, 1930, pp. 94–110.

LOOMIS, FREDERIC BREWSTER: "Field Book of Common Rocks and Minerals," New York: G. P. Putnam's Sons, 1927, 278 pp.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book V, New York: Silver, Burdett and Company, 1935, pp. 61–72.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 299–311.

*——— and ———: "Nature and Science Readers," Book IV: "The Work of Scientists," New York: The Macmillan Company, 1935, pp. 3–27.

*PERSING, ELLIS C., and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 191–209.

*PHILLIPS, MARY GEISLER and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book IV: "Our Earth and Its Life," Boston D. C. Heath & Company, 1936, pp. 49–146.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 97–104.

STARTING A SCHOOL MUSEUM

Aims

A very wide range of interests in the things around us, with consequent increased ability to find enjoyment. A limited knowledge of many things.

Suggestions

Children have a marked tendency to collect things; and if teachers show an active interest in the objects brought in, there will be no dearth of materials for the museum. A few shelves should be put up, preferably in the classroom rather than in the storeroom, to hold the collection. A wall case may be cleared for the purpose. Provide all the room you can, for it is likely soon to be overflowing.

Do not make the mistake of rejecting all but unique and valuable curios. Almost any kind of object capable of being housed in the museum should be accepted. Something interesting can be developed concerning it.

The teacher may not know enough about the object at the time that it is brought to her to develop great interest in it. Many of the objects will be received at times when she can hardly take the time to talk about them. In both of these situations she need only show interest in the contribution and say, "We shall talk more about it soon at a science period." A little study on the part of the teacher will reveal interesting information about even the most ordinary things, such as a rusty nail or a fragment of colored glass.

Making such a museum not only has informational value but is a very effective way of developing a wide range of interests and satisfactions. The value lies in the activities associated with collecting and talking over the finds. The museum has very little value for the next grade and may be largely discarded after the close of the school year.

No containers are needed for most objects. For those which are small, light, round, or easily broken, cardboard boxes or discarded glass containers such as sandwich-spread jars can be used.

Each week a curator or caretaker of the museum should be appointed. His duties are to keep the museum clean and in order, to receive and label contributions, to check out specimens needed for any purpose, and to explain the collection to visitors. The labels should have spaces for the name of the object, the name of the contributor, place obtained, and remarks.

It is not possible to list here all of the types of objects likely to be brought in for the museum, but experience shows that many of the following general classes of materials will be included: scraps of metal, parts of machines, crockery and glass fragments, rubber, cloth, woods, seeds and fruits, leaves, mushrooms, feathers, shells, bones, deserted nests, galls, and insects in all stages. Many interesting things will be contributed by persons who no longer care to keep them in the homes.

Contributing Learnings

The informational outcomes will vary with the materials collected. It is obviously impossible to state these outcomes for all the collections that may be made, and it would require much more than the space here allotted to a single activity. The important idea to be developed is that there are interesting things to find out about every object.

References

*HALL, A. NEELY: "Big Book of Boys' Hobbies," Boston: Lothrop, Lee & Shepard Company, 1929, pp. 206–216.

MANN, PAUL B. and GEORGE T. HASTINGS: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 338–346.

PAYNE, FRANK OWEN: "One Hundred Lessons in Nature Study," Chicago: Beckley-Cardy Company, pp. 11–13, 101–105.

VERRILL, A. HYATT: "Harper's Book for Young Naturalists," New York: Harper & Brothers, 1913, pp. 3–17, 327–330.

*———: "The Boy Collector's Handbook," New York: Robert M. McBride & Company, 1927, 290 pp.

WINTER SCIENCE ACTIVITIES FOR THE ELEMENTARY SCHOOL

KEEPING A WINTER NATURE CALENDAR

Aims

Interest in the changing seasons.

Experience contributing to the generalizations that the sun largely controls conditions on the earth and that natural law prevails.

Health through adapting living to seasonal conditions.

Suggestions

This is essentially a continuation of the fall weather calendar and can be carried out in much the same manner. See the suggestions for the activity "Keeping a Nature Calendar" in the outline for autumn.

In addition to observing and recording sunny and cloudy days, wind direction, storms, temperature, and length of day, it is well to include significant winter changes such as first freeze, period of snow cover, freezing over of lakes and streams, damaging sleets, icy roads, blockaded highways, thaws, and other winter happenings.

Some teachers prefer to use a sheet of plain tagboard or a bulletin board for each month and to record only outstanding happenings instead of keeping daily records. The daily record shows gradual seasonal change and is to be preferred for children beyond the kindergarten.

Contributing Learnings

The sun appears far to the south of us in winter and does not furnish so much heat. It shines here for a much shorter period each day than in summer.

We must provide more heat and keep more of it from escaping. Building fires, eating more energy foods, and exercising more give us added heat. Most of our food is used as fuel to heat the body. Exercise uses food, but most of this food gives heat. By wearing heavier clothing, especially wool, we keep much of this extra heat from escaping. There is a layer of warm air

inside our clothing. We keep more of the heat in our homes by closing windows, using window and door strips, putting on storm doors and windows, and in many places in the North by banking around the foundation. We roll up awnings to let the sun shine into the house. In summer we wish to have the heat produced by our bodies escape.

Moisture freezes in the cold air in winter and falls mostly as snow. When the snow is driven by a high wind, we call the storm a blizzard. Snow interferes with many of our activities, but it protects plants, supplies moisture, and brings us winter sports. Snow is beautiful.

Moisture condenses out of the air on cold objects, forming frost. Frost kills plants, but it is often very beautiful.

We notice the cold a great deal at first, but our bodies soon become adjusted to it. We need to be out-of-doors part of the time in winter in order to get as much as possible of the lessened amount of sunshine.

Overheating and severe chilling give diseases a good chance to attack us. We must not keep our homes and schoolroom too warm and must avoid gradual and long chilling.

Air cools faster than water. The water does not freeze over until we have had freezing weather for some time.

The sun warms the earth during the day, sometimes causing snow and ice to melt. Night temperatures are generally lower than day temperatures.

We cannot always tell how cold it is by the way we feel. On windy days the perspiration evaporates from our skins rapidly, making us feel cold. The thermometer tells the temperature. The mercury in the thermometer expands with heat and shrinks as it loses heat.

Each day the sun appears farther to the south of us, until on Dec. 21 its rays are most slanting. People far to the south of us are having summer while we are having winter. After that time the sun begins to appear more nearly above us each day. Our coldest weather often comes in January, as it takes the sun some time to warm the cold part of the earth again. When the heat of the sun has melted the snow and ice and has warmed the earth enough so that growth can start rapidly again, we say that it is spring, though the weather may still seem chilly to us.

The change in seasons is a regular event in nature. Before people understood this, they tried in many ways to appeal to

the gods and insure the coming of the next growing season. We cannot influence these changes. We can be sure that they will come and plan to be ready for each season.

References

BEEBE, CHARLES WILLIAM: "Log of the Sun: A Chronicle of Nature's Year," Garden City, New York, Garden City Publishing Company, 1906, 321 pp.

**Cornell Rural School Leaflet*, Vol. 23, No. 2: Through the Year, Ithaca, N. Y. Cornell University, November, 1929.

**Cornell Rural School Leaflet*, Vol. 25, No. 3: In the Woods in Winter, Ithaca, N. Y., Cornell University, January, 1932.

*CRAIG, GERALD S., and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 5–81.

HOWES, PAUL GRISWOLD: "Backyard Exploration," Garden City, New York, Doubleday, Doran & Company, Inc., 1927, pp. 18–20.

JOHNSON, GAYLORD: "Nature's Program," New York: Doubleday, Doran & Company, Inc., 1926, pp. 146–173.

PACK, ARTHUR NEWTON, and E. LAURENCE PALMER: "The Nature Almanac." Washington, D. C.: The American Nature Association, 1927, pp. 6–29.

SHARP, DALLAS LORE: "The Year Out-of-doors." Boston: Houghton, Mifflin Company, 1914, pp. 25–31.

MAKING SCRAPBOOKS OF WINTER SCENES AND SPORTS

Aims

Enjoyment of the winter season.

Increased safety through understanding of some of the dangers of the winter season.

A sympathetic and helpful attitude toward other forms of life.

Experience contributing to the generalization that the sun largely determines conditions on the earth.

Suggestions

The scrapbook may contain pictures of winter clothing, snowstorms, blockaded highways, snowed-in automobiles and trains, snowhouses, snowmen, snow-laden trees and other objects, beautiful winter scenes, sleds, dog teams, skiis, types of skates, skating parties, winter bathing in the south, accidents, winter birds and other animals searching for food in the snow, evergreens, deciduous trees in their winter condition, and occupations carried on only in winter such as cutting and storing ice.

The pictorial sections of the Sunday newspapers contain many excellent photographs of seasonal subjects. Magazines also afford good material. Local photographs are even more interesting. Most suitable of all are pictures of the children engaged in winter activities, pictures of their homes, and other familiar scenes.

In addition to pictures, there should be poems, drawings, and simple accounts of some of the children's experiences during the winter.

Contributing Learnings

Snow is a light solid. It cannot soak into the ground until it melts to liquid form. It melts only when the temperature rises above 32° (Fahrenheit).

The snow forms a blanket over the ground in the north, keeping the ground from freezing as deeply as it otherwise would and protecting plants somewhat from winter injury. The weight of the snow on the branches of trees sometimes breaks them.

The snow, being light, is blown about by the wind. Where the sweep of the wind is checked or objects hold the snow, drifts are

formed. These drifts sometimes cause people to be snowbound in their homes, in automobiles on blocked highways, and in stalled trains. Snow fences help to catch the snow which might otherwise form drifts on highways. It is wise to hurry to some place of safety when the snow is drifting and the weather is very cold.

Packed snow and ice are smooth. There is little friction when objects rub against them. The wheels of our automobiles slip badly on them, causing many accidents. We must drive and walk carefully. Sled runners and skates soon wear smooth and slide easily over the snow and ice with little friction. Sharp skates have square edges which do not slip easily on the ice when we push back against them to go forward and when we wish to turn. The bottoms of the runners are smooth, allowing us to glide forward. Dull skates have round edges which slip badly.

The surface of the water freezes first. Flowing streams freeze later than ponds. The warmer deeper water mingles with the colder surface water of flowing streams. Water above freezing temperature seeps out of the unfrozen deeper soil along streams and delays freezing. For these reasons streams are often open well into winter. Where water from streams and springs enters lakes, the ice is apt to be very thin. It is important to wait until the ice has been tested and pronounced safe before skating on it.

Animals can be active only when they are warm inside. Only birds and hairy animals keep a warm temperature during winter. The other animals are either less active or in a sort of sleep during winter. This is true even of some of the hairy animals. Warm-blooded animals require a great deal of food. Food is the fuel that makes body heat. Winter is a hard time for active animals to find enough food. During heavy snows we ought to feed the birds. Sometimes the other animals need help. Mice and rabbits often ruin trees and shrubs by eating the bark during winter. It is wise to place guards around valuable plants.

The sun largely governs conditions on the earth. In winter when it appears far to the south of us, fewer of its rays reach us. Thus the sun governs the appearance and conditions on the surface of the earth and the activities of its creatures, including man.

WATCHING THE CHANGING DAY

Aims

Orientation with reference to the periods of the day.

Interest in the changing sky.

Experience contributing to the concept that the sun largely determines conditions on the earth.

Suggestions

Strange as it may seem to adults, daily changes are one of the most confusing aspects of the environment to the young child. Many children starting to school are confused about the periods of the school day.

Let the children express their observation of the early morning sky by means of crayon sketches, paper cutting, and description. Do the same for other periods of the day and evening. For this purpose choose clear weather when you are able to observe the apparent changes in the position of the sun throughout the day and the moon and stars in the evening.

Observe the changes and make sky pictures on partially cloudy days during alternate periods of sun and shade. Collect pictures made with the use of a ray filter showing cloud effects. See who can discover the most beautiful sky view. Note the brightness and feeling of warmth when the sun appears from behind the clouds. Watch the clouds scurrying across the sky, showing that the wind is blowing high up above the earth. Try to decide what the clouds are. Note whether the wind direction is the same up at cloud height as it is on the earth.

Observe the moon in relation to the changing day. Discover whether clouds also shut us off from the starlight.

Continue the activity until children comprehend the regularity of the periods of the day and become interested in watching the ever changing sky.

Contributing Learnings

The sun gives us light and heat on the earth. When it is shining on us, we have daylight. Moonlight is sunlight reflected by the moon, as a mirror reflects lights that we cannot directly see.

Clouds are largely moisture and dust in the air. They are driven along by air movements. They shut off our vision of the sun at times and greatly reduce the amount of light reaching the earth. Sometimes moisture falls from the clouds as rain, snow, sleet, or hail.

The sun seems to rise in the east. It seems to rise higher in the sky during the morning and warms the earth a great deal. By noon it appears high above us and directly to the south. It seems to move westward during the afternoon and, at sunset, disappears from sight in the west. The moon seems to follow the same direction and order.

Watching the sunrise and sunset is one of our greatest joys. The dust and clouds in the air cause an endless variety of colors and shapes. By observing the position of the sun, we are able to guess the time.

The stars also give us some light; but when the sun is shining, the light is so bright that we are unable to see them. We can understand this if we turn on an electric light and look toward it and the sun at the same time, for the sun is so bright that we do not see the electric light.

References

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 133–151.

*——— and ———: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 33–35.

*HYMAN, MARY WATSON, and others: "The Find Out Book," Vol. I, Chapel Hill, North Carolina, University of North Carolina Press, 1934, pp. 106–112.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III, New York: The Macmillan Company, 1933, pp. 242–264.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 53–60.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 50–54, 124–130.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 131–134.

SCHMUCKER, SAMUEL CHRISTIAN: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 247–255.

*SMITH, JEANETTE: "Sun, Moon and Stars," Columbus: American Education Press, 1935, 36 pp.

LEARNING TO TELL DIRECTION

Aims

A sense of orientation and satisfaction through ability to reduce to order the confused arrangement of objects in the environment.

Ability to follow directions and find one's way.

Simple foundational experience for developing a directional space concept through later studies of rotation, revolution, and relative movements.

Suggestions

Locate south by the position of the sun at noon. Locate north by facing in the opposite direction. Extend the arms sidewise to locate east and west. Point out objects in each of the four directions from the school.

Discover which direction the school and near-by buildings face. Observe where sunlight falls on the building at noon and which rooms receive direct sunlight. Study streets and roads to discover in which directions they lead. Try to determine in which direction neighboring towns and local points of interest are located.

Cut out arrows from cardboard. Label them north, south, east, or west, and pin them to trees and objects about the school.

Discover the direction of the wind by tossing light objects into the air and by wetting the inside of the hand and noting the cooling effect of the evaporation. Read the wind direction from a weather vane.

Play games involving directions. Name a child, and ask him to run in a certain direction. If he succeeds, he may name another child and indicate a direction. When north, east, south, and west have been mastered, add the intermediate directions. Let one child direct another to run in some direction until he hears the command to stop. By giving further commands he should bring the runner back home to the starting point. Move to a new location when directions have been mastered.

Locate addresses on a city map, as 810 West Fourth street.

Look for green plants (mosses, algae, lichens) growing on the bark of trees. Discover on which side of the tree they are grow-

ing, and consider possible reasons for this fact. Use this method to determine direction in a park or woods.

Upper-primary children may be able to use the watch method. Hold the watch (an alarm clock is better to use at first) with the hour hand pointing in the direction of the sun. Halfway between this direction and twelve o'clock on the timepiece is approximately south.

It is not difficult to locate the North Star at night. First look for the Big Dipper the two outer stars of which point almost directly toward the North Star. Parents will be glad to cooperate if the child is given a chart to take home such as may be found in the references cited on page 250.

Continue until the children can tell direction by a number of methods. Talk over the great value of the different methods to travelers and persons lost in the woods or at sea. Decide which method you would use in each case.

See the directions for holding a treasure hunt among the suggestions for the activity "Experimenting with Magnet and Compass."

Contributing Learnings

In laying out cities, roads, and tracts of land, the north-south and east-west directions are usually followed. This makes it much easier to find our way about and to describe locations. We make daily use of directions in many ways.

Some objects, such as our homes, roads, and school, keep the same direction. The directions of the sun and moon seem to change in an orderly way from east to west. The direction of the wind (air in motion) and of movable objects veers about.

The sun appears to rise in the east, is directly south of us at noon, and seems to set in the west. Some of our schoolrooms are on the north side of the building and never get direct sunlight. Others have east windows and receive morning sun. Those on the south side receive sunlight most of the day. Rooms with west windows receive afternoon sun. Since our homes face different directions, we have different lighting.

The sun dries out the soil and the leaves of the plants on the south side of buildings, and only plants able to withstand these conditions will grow there. We plant most of our flowers on the south, east, and west sides of the building, as sun is needed for blossoming. Only shade-loving plants grow well on the north

side of buildings. The outer bark of trees is a dry place for plants, and they are usually able to grow only on the north side of tree trunks where the sun does not shine directly upon them. By examining the trees we can tell direction and find our way in the woods.

By locating the North Star we can tell direction at night.

References

*Beauchamp, Wilbur L., Gertrude Crampton, and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 129–130.

*"Handbook for Boys," New York: Boy Scouts of America.

*Edwards, Paul Grey, and James Woodward Sherman: "The Nature Activity Readers," Book III: "The Outdoor World," Boston: Little, Brown & Company, 1931, pp. 255–270.

*Girl Scout Handbook," 570 Lexington Avenue, New York: Girl Scouts, Inc.

*Persing, Ellis C., and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 142–148.

LEARNING TO GUESS TIME BY THE SUN

Aims

Interest in guessing and telling time.

Ability to guess time and to orient oneself with respect to time relationships.

Simple background experience contributing to concepts that the sun largely determines conditions on the earth, that the duration of time is beyond our power of comprehension, and that we can depend on natural law.

Suggestions

Compare the position of the sun in the early forenoon and late afternoon. Note its position at noon.

If the room has windows on the south side, it will be possible to use the vertical edge of a window sash, the division between the panes, or some upright object near the windows as a shadow stick. Otherwise, a stake can be set in the ground out-of-doors. Mark on the floor or ground the position of the shadow at exactly twelve o'clock noon. Learn to tell early morning, near noon, a little after noon, and late afternoon by the shadows. Note also that the shadow is shortest at noon. Now mark the position of the shadow each hour of the school day.

Practice guessing time by the shadows and checking the guesses by consulting the clock. Continue until all of the children can fairly accurately determine the time by the shadow stick.

Now erase all of the marks except that of the noon shadow, and continue the practice in guessing time.

Choose other stationary objects on the school ground, such as trees and posts, as shadow sticks. Most buildings face north, south, east, or west, and their shadows offer a good opportunity for guessing time.

Use the shadow cast by the human body as a basis for guessing time, considering both the direction and the length of the shadow.

Finally, practice guessing time by direct observation of the sun's position, using the shadows of various objects as a check.

Contributing Learnings

Time is determined by our change of position in relation to the sun.

These changes take place regularly. We can come to understand them and plan our affairs accordingly, but we cannot control them.

The sun is very important to us. It determines our daily round of rising, going to school, returning, going to bed, etc. But it also means much more than this to us. It gives us our heat and light and makes life possible.

The sun appears in the east in the morning. It seems to move westward during the day. At noon it is directly south of us. In the afternoon it appears in the west. The time in other places will not be the same as it is here, for the people there will call it noon when the sun is directly south of them.

Many peoples worshiped the sun. This need not seem strange to us, for the sun largely controls our lives.

Time has probably gone on in this manner longer than anyone can realize, and it will likely go on and on.

Days are long, the nights short in summer. In spring and fall days and nights are about equal in length. In winter the days are short, the nights long. We need to remember this in guessing time by the sun and in planning our affairs.

References

*Beauchamp, Wilbur L., Gertrude Crampton, and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 125–129.

*———, Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 127–130.

*"Handbook for Boys," New York: Boy Scouts of America.

*Ilen, M.: "What Time Is It?" Philadelphia: J. B. Lippincott Company, 1932, 132 pp.

*Lansing, Marion Florence: "Great Moments in Science," Garden City, New York: Doubleday, Doran & Company, Inc., 1926, pp. 93–116.

*Persing, Ellis C., and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 151–160.

MAKING EVENING SKY MAPS

Aims

A broader concept of the vastness of space. Some realization that man's concept of truth changes.

A degree of prophylaxis against the propaganda of astrologers and their unscrupulous preying on humanity.

Greater enjoyment of the night sky.

Suggestions

The observational part of the activity must obviously be carried out at home, but it is well to get the group together one evening. Winter is a good time for the activity. The stars can be seen very early in the evening, and there is less moisture in the air to obscure the view. Choose a time between the last and first quarters of the moon (a new moon is good), when the moonlight will not be so bright as to prevent a good view of the stars.

First let the children watch for the moon. Ask each child to cut with scissors a piece of paper the shape of the moon. Have the pictures brought to school for comparison. Let them discover its location at a given time.

Secure some heavy blue paper to represent the sky as it appears, or let the children color ordinary heavy paper or cardboard blue. Cut moons from gold- or silver-colored paper, and paste them in position.

Draw the stars of the Big Dipper and the North Star on the blackboard. Let the children locate them in the evening sky, asking help from the parents, if needed. When the children have agreed on their location, let them paste these stars on their sky maps. (Packages of silver stars can be purchased locally.)

Now add the Little Dipper to the drawing on the blackboard, and proceed in like manner.

Look for the Milky Way, and paste many small stars on the sky map to represent it. A few of the other bright stars may be added, but young children cannot be expected to learn many constellations.

The monthly map of the evening sky in *Nature Magazine* is quite helpful. There is nothing equal to a star finder or planisphere, as it has been called, for the purpose. Professor E. Laur-

ence Palmer of Cornell University has prepared such a planisphere which can be assembled in a few minutes by any intermediate-grade pupil. By turning the star finder until the proper date is above the proper hour, a map of the sky at the particular time is exposed. The star finder is then held overhead as one looks at the sky. The planisphere is included in *Cornell Rural School Leaflet*, Vol. 23, No. 3, The Sky at Night.[1] Each child should have a planisphere.

When the children have learned to locate the Pole Star, the Big Dipper (Ursa Major), the Little Dipper (Ursa Minor), a very few of the many other constellations, and any planets visible at the time, it will prove interesting to make sky maps at intervals during a clear evening. While making the maps, face toward the Pole Star, and locate it in the center of the paper. Begin early in the evening, and make three maps at two-hour intervals. Exhibit and discuss the maps at school the next day.

Try to count the number of stars in at least a portion of the sky. Find the brightest stars. Find out all you can about the sun, stars, planets, and satellites. Learn when a shower of meteors is expected. Watch for them and count them.

Compare our ideas of space today with that of the ancients. Listen to the broadcasts of the astrologers, and discuss whether that is what we learn from the stars. Use the star finders again in the spring, and compare the observations with the winter maps.

Look for the moon during the day. Try to decide why it is not brighter. Turn on the electric light, or light a candle while the sun is shining into the room. Notice whether it appears as bright as it does at night. Help the children to understand that the stars are also shining during the day but that we do not see them. Let them explain why they seem to come out one by one as it grows darker. Discuss why they cannot be seen on some evenings.

Check the time of appearance and the phase of the moon on some calendar or almanac against your observations.

Contributing Learnings

The moon seems to be the brightest object in the night sky because it is closer than the stars. Direct sunlight is much brighter than moonlight. Therefore, we hardly notice the moon

[1] The *Cornell Rural School Leaflets* are obtainable from Cornell University, Ithaca, New York, at 50 cents per year. Some back numbers are available.

while the sun is shining on us. Night gives us a chance to see a little of what lies beyond us in space.

The stars are so far away that we do not receive much light from them. When the full moon is shining, its light seems so much brighter that we may not see the stars. Some of the stars are much brighter than others. The brighter ones appear first as it grows dark in the evening. Sometimes the clouds shut out the light of the stars and moon.

Our earth is not the center of the universe. It is one of the smaller bodies or planets revolving about the huge sun. The stars are other suns. We are about 93,000,000 miles distant from the sun. The other suns are much farther away, and many of them are much larger. One can see about five to six thousand of these suns without a telescope. With our larger telescopes one can detect more than half a billion of them. A new 200-inch reflector has revealed many more.

We receive our heat and light from the sun. Because we are closer to it, our sun seems brighter than the others. When our side of the earth is turned toward the sun, we cannot see the other suns. At night we see these suns as stars. We also see the light of our sun reflected from the moon.

The moon is a smaller body about one fourth the diameter of the earth and revolves about it once in about twenty-nine and one-half days. As the moon shines only by reflected light from the sun, we see only the portion of the lighted part that is turned toward us. This causes the regular changes of the moon as we see it. Irregularities on the surface of the moon make up the face of the "man in the moon."

The Pole Star is so nearly in line with the axis of the earth that its apparent position does not change as the earth rotates. As the earth rotates from west to east, the other stars seem to move westward. Stars farther from the Pole Star may disappear below the horizon.

The planets, being much closer to us than the stars, give a steadier light. Other suns probably have planets.

We do not know how far space extends. Our ideas have changed greatly, and there are discoveries in this field every year. The idea of the earth and of man as the central features of a very limited universe is no longer acceptable.

It is not true that the particular part of the great system of constellations visible at the time of the birth of any individual,

or at the time when he undertakes some venture, will determine his success or failure. Astrologers prey on people in this manner in order to get money from those who do not have a scientific view of the universe.

References

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 131–136.

*———, HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 131–139.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 887–904.

Cornell Rural School Leaflet, Vol. 15, No. 1: Teacher's Number, Ithaca, New York: Cornell University, September, 1921.

**Cornell Rural School Leaflet*, Vol. 23, No. 2: The Sky at Night, Ithaca, New York: Cornell University, January, 1930.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 141–150.

*——— and ———: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 16–32.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 145–152, 161–194.

*——— and GOLDIE S. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 3–28.

*DOUGAN, LEWIS M.: "Stories of Outdoor Science," New York: Lyons and Carnahan, 1933, pp. 315–349.

FROST, EDWIN BRANT: "Let's Look at the Stars," Boston: Houghton, Mifflin Company, 1935, 118 pp.

MANN, PAUL B., and GEORGE T. HASTINGS: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 299–314.

MOSELEY, EDWIN LINCOLN: "Trees, Stars and Birds," Yonkers-on-Hudson, N. Y.: World Book Company, 1932, pp. 190–195, 228–231.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 255–275.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 130–148.

*PATTERSON, ALICE JEAN: "Nature Study and Health Education for Sixth Year," Normal, Illinois: McKnight and McKnight, 1927, pp. 65–81.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 53–57.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 112–116.

*—— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 135–141.

*—— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 159–167.

*—— and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 137–158.

SCHMUCKER, SAMUEL CHRISTIAN: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 247–255.

*SMITH, JEANETTE: "Sun, Moon, and Stars," Columbus: American Education Press, 1935, 36 pp.

*TRAFTON, GILBERT H.: "Nature Study and Science for the Intermediate Grades," New York: The Macmillan Company, 1927, pp. 210–226.

DEMONSTRATING NIGHT AND DAY AND THE CHANGING SEASONS

Aims

A broader concept of the vastness of space. A greater realization that phenomena that seem miraculous and give rise to superstition are explainable on the basis of natural law.

Interest in solar and cosmic phenomena.

Suggestions

Let the pupils plan the demonstration and carry it out. See that the demonstration is perfected until it is effective and convincing.

A darkened room is almost essential. This can usually be arranged in the hall, basement, or some large closet by covering any apertures with black building paper. More demonstrations of these phenomena are rendered ineffective by failure to exclude the bright light than in any other manner.

A bright light emanating in all directions is needed to represent the sun. A gasoline lantern is very effective but not quite so safe as an Aladdin lamp. A small pencil-point flashlight makes a convenient pole star. A small globe will represent the earth, and a baseball or other smaller sphere that will reflect a fair amount of light will do for the moon.

The demonstration can be built up gradually and finally operated as a whole to show all processes going on simultaneously.

Rotate the globe while keeping the North Pole pointed in the direction of the Pole Star to demonstrate night and day. Discover what period of the day or night is being experienced in various parts of the world at the time of the demonstration.

Carry the globe in a wide circle about the lamp, keeping the north pole pointed toward the Pole Star. Locate the Pole Star above the globe so that the axis of the latter may be inclined about 23½ degrees (globes are mounted to stand at this angle) and as far from the earth as possible. Work out the seasons for the Northern Hemisphere; for the Southern Hemisphere.

Carry the ball in a smaller circle about the earth to demonstrate the phases of the moon. With your eye near the globe, watch the visible lighted portion of the moon change. To demonstrate

why we always see the same side of the moon, let one child acting the part of the moon walk in a circle about the earth globe, always keeping his face toward it, as the moon rotates only once while making a complete revolution.

Demonstrate eclipses of the moon and sun.

Encourage the pupils to read as much as possible about the universe. Calculate together how far the pencil flashlight representing the North Star should be placed from the earth to maintain the same scale used in locating the lamp (sun) and globe (earth). To simplify the calculation, the globe may be placed ninety-three inches from the sun. One inch will thus represent one million miles.

Let the children work out a clear explanation of the phenomena demonstrated and present it cooperatively as an illustrated lecture before other groups.

Contributing Learnings

Stars are large bodies somewhat like our sun. They are so far away that it takes many years for their light to reach us. If in our demonstration we place the globe representing the earth ninety-three inches from the lamp representing the sun (instead of about 93,000,000 miles, as it really is), we should need to place the pencil flashlight representing the Pole Star about 3700 miles away to maintain the same scale. Instead of the pencil-point flashlight, we should need a huge arc lamp to represent Polaris, the Pole Star, as it is many times larger and brighter than our sun. There are other stars larger and brighter than Polaris.

Our earth is a small body compared to the sun and stars. The sun gives it heat and light.

The earth is turning or rotating all the time. The side of the earth facing the sun receives light while the other side is having night. The earth makes a complete rotation every twenty-four hours. As the earth rotates from west to east, morning and evening come earlier to the east of us, later to the west of us. We notice this in traveling and in the radio-broadcasting schedules, of the east coast, the central states, the mountain states, and the Pacific coast stations.

The earth is always moving through space in a path (orbit) about the sun, making a complete journey in one year. The stars are so far away that their position changes very little with reference to the earth. The axis of the earth points almost exactly

toward the Pole Star at all times. During one part of the earth's journey about the sun its northern half or hemisphere is more exposed to the sun. Then we have summer. Six months later, when the earth is at the opposite side of its orbit, the Southern Hemisphere receives more sunlight. Then it is summer in the Southern Hemisphere and winter in the Northern Hemisphere. Halfway between these points in its orbit the Northern and Southern Hemispheres receive equal amounts of sun energy. These are the spring and fall seasons.

During our summer, when the Northern Hemisphere receives more of the sun rays, our days are long and warm. Winter days are colder and shorter.

The moon moves in an orbit about the earth, completing its circuit in a little less than our average calendar month. The same side of the moon is always toward the earth, as it rotates only once while making a complete revolution. Moonlight is sunlight reflected from the moon. The moon seems to change shape because we see only the portion of it turned toward the sun, at that point in its journey, which is also in the half facing the earth.

When the moon comes between us and the sun, it prevents sunlight from reaching the earth, causing an eclipse of the sun. When the earth is between the sun and the moon, sunlight cannot reach the moon. As the moon shines only by reflecting light from the sun, we cannot see it during these times. Usually, the light is cut off from only part of the sun or moon, and we have a partial eclipse. The part of the sun or moon hidden from view differs with our location on the earth.

The movements of the stars, planets, and satellites are regular and can be foretold by astronomers. Astronomy is a scientific study. Astrologers deal with the imagined influence of the movements of heavenly bodies on man.

References

COMSTOCK, ANNA BOTSFORD: "The Handbook of Nature-study," Ithaca, N. Y.: Comstock Publishing Company, 1911, pp. 913–923.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science, Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 5–58, 227–236.

*——— and BEATRICE DAVIS HURLEY: "Pathways in Science, Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 51–65.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 145–194.

*——— and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 3–50.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book III: "The Outdoor World," Boston: Little, Brown & Company, 1931, pp. 77–88.

FROST, EDWIN BRANT: "Let's Look at the Stars," Boston: Houghton, Mifflin Company, 1935, 118 pp.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book V, New York: Silver, Burdett & Company, 1935, pp. 73–84.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 242–278.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 131–148.

*PAYNE, GEORGE E., HENRY E. BARROWS, and LOUIS J. SCHMERBER, "Elementary Science Readers," Book II, Boston: Benjamin H. Sanborn & Company, 1927, pp. 209–223.

*PERSING, ELLIS C., and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 137–158.

*SMITH, JEANETTE: "Sun, Moon and Stars," Columbus: American Education Press, 1935, 36 pp.

WASHBURNE, CARLETON, and HELUIZ WASHBURNE: "The Story of Earth and Sky," New York: D. Appleton-Century Company, Inc., 1933, 368 pp.

TRACING OUR RELATIONS WITH THE REST OF THE WORLD

Aims

Some realization of our dependence upon the environment and of our interdependence in a scientific age.

Appreciation of other peoples and of the possibilities for enriched existence through cooperation.

Suggestions

Sixth-grade children have enough knowledge of geography to make this activity meaningful. It has been used in the fifth grade.

Find out where the things come from that we use. Visit wholesale groceries and other wholesale houses as a group if suitable arrangements can be made. Record where we get various fruits, vegetables, meats, cereal foods, spices, utensils, clothing, machines, vehicles, paper and publications, building materials, etc.

Discover by interviews, visits, and other means which products are shipped out of the community and where they go. Companies are usually glad to supply such a list.

Construct a large world map on a bulletin board or a large section of wall board—the larger the better. Connect with your own city or locality, by means of lines, all of the places on the map to which local products or raw materials go or from which you get them. Use one color of line for community imports and another for its exports. Pupils under one teacher prepared a large portable display chart which was on exhibit downtown and aroused much community interest and comment. Thumbtacks and colored strings were used instead of lines. The display can be made more realistic by mounting small samples of products and pictures of the more perishable ones.

Study and discuss why production of the items shown on the chart is centered in those localities.

List services (other than products) either received from other regions or furnished to them.

Contributing Learnings

(Only general principles can be given here, as the specific learnings will vary with the location of the school.)

We depend upon other parts of this country and upon almost all other countries of the earth for many of the things we use. On the other hand, we supply some of the needs of many peoples outside our own community. We depend upon each other. By cooperating, we and they can have a richer existence. If we fail to cooperate, we both lose.

The reason for the distribution of production is generally to be found by studying the environment. Often it is in the climate. Some food plants will grow only in warm climates. Other crops, such as potatoes, yield heaviest in the long daylight periods of the North. The unequal distribution of mineral resources makes it advisable to share and cooperate. Some cities have good harbors and natural transportation routes. Some regions have coal deposits and water power. They help the rest of the world by manufacturing out of raw materials the articles that we need. Other regions have good soils and waters for producing food, clothing materials, etc.

The discoveries of science have made it possible to transport products quickly and to preserve them for movement over the earth. Various parts of the earth are suited to furnish certain of the things that people over the world need and desire. We need cooperation now, not war and strife. We are interdependent.

References

ALLEN, NELLIE B.: "Cotton and Other Useful Fibers," Boston: Ginn and Company, 1929, 368 pp.

*CAMP, RUTH ORTON: "The Story of Markets," New York: Harper & Brothers, 1929, 118 pp.

*CARPENTER, FRANK G., and FRANCES CARPENTER: "The Clothes We Wear," New York: American Book Company, 1926, 198 pp.

*——— and ———: "The Foods We Eat," New York: American Book Company, 1925, 181 pp.

*——— and ———: "The Houses We Live In," New York: American Book Company, 1926, 204 pp.

*PETERSHAM, MAUD, and MISKA PETERSHAM: "The Story Book of Food," Philadelphia: John C. Winston Company, 1933, 32 pp.

*WORTHINGTON, JOSEPHINE, and CATHERINE VICTORIA MATTHEWS: "Our Clothing," Dansville, New York: F. A. Owen Publishing Company, 1931. 256 pp.

MAKING A STUDY OF A SNOWFALL

Aims

Interest in the snow and enjoyment of the winter season.

Some understanding of the effects of snow on living things and of our adjustments to it.

Suggestions

It is well to plan the study with the children at the first sign of snow in order to be ready to take advantage of the first heavy snowfall.

Observe how the snow falls, comparing the movement of the flakes with that of raindrops.

Catch snowflakes on pieces of black paper, and examine them with a magnifying lens. Try to reproduce some of the designs. Compare snowflakes with a bit of lace. Note whether or not any snowflakes are broken. Observe that the masses which appear to be large flakes consist of many flakes clumped together. Press some snow into a ball, and examine with a lens.

Observe how soon the ground is covered with snow and where drifts are forming. Try to recognize snow-covered objects.

Discover which trees bear the heaviest loads of snow. Note whether any branches are badly bent or broken.

When the snowfall ceases, measure the depth in several places in some open area. To find how much water fell in the form of snow, catch the snow in a straight-sided vessel, or fill such a vessel with unpacked snow to the depth found by previous measurement, and measure the depth of the water in the vessel after melting the snow. Find how much snow must fall to equal one inch of rain. Find how much water there is in packed snow. Bring some snow into the schoolroom. Place it on some dirt, and watch it melt and sink into the the soil.

Raise the question as to whether the blanket of snow on the earth keeps the ground and the buried plants warm or makes them colder. Let the children plan an experiment with a thermometer to solve the problem. Take the air temperature, and then thrust the thermometer back under the snow cover until the mercury bulb is near the ground. After a time, remove the ther-

mometer, and read the temperature promptly before the mercury has time to cool. Repeat until you are sure of your results. Also compare the temperature of exposed surface soil and that under a snow cover.

Make a small snowhouse such as Eskimos and travelers in the north sometimes use. Discover how much protection it gives.

Shovel paths, and, if possible, watch the snowplows.

Observe the different kinds of sleds and sleighs. Try to secure a pair of skiis and some snowshoes, and learn to use them.

Contributing Learnings

Snowflakes are formed of many crystals of moisture gathered together. They are always six pointed, but no two seem to be exactly alike. The snowflakes are very beautiful, and their patterns make excellent designs. When the snow is crushed, the crystals are broken and partly melted. They then mat together and become more like ice.

Snow drifts wherever there is anything to break the wind and check the movement. Many objects take on interesting shapes and are quite beautiful when covered with snow.

A great deal of snow collects on the evergreens. The burden of snow makes the branches droop and frequently breaks some of them.

Much snow falls in the colder regions each winter, but it requires many inches of snow (as many as sixteen) to equal one inch of rainfall. The amount of water furnished by any depth of snow depends upon how packed or loose it is. If the ground is not frozen and the snow melts slowly, the water sinks into the soil where it affords moisture for plants.

The snow acts as a blanket to prevent the surface of the earth from freezing to such a great depth. It is a protection to plant and animal life.

Snowhouses protect people from extreme cold and are sometimes used where the snow will not melt and where other materials for building homes cannot easily be had.

Snow blocks sidewalks and roads, interfering with travel, but it makes possible other means of travel. Wheels cut down into the snow. To travel over snow we need broad snowshoes, skiis, or long sled runners which the snow will support. Moreover, wheels slip badly in snow and spin around without driving our cars forward.

References

BENTLEY, WILSON ALWYN, and W. J. HUMPHREYS: "Snow Crystals," New York: McGraw-Hill Book Company, Inc., 1931, 227 pp.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature-study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 850–856.

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 100–109.

*——— and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 103–105.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 111–120.

FREE, E. E., and TRAVIS HOKE: "Weather," New York: Robert M. McBride & Company, 1928, pp. 134–143.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 77–97.

*PERSING, ELLIS C., and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 125–134.

SHARP, DALLAS LORE: "The Year Out-of-doors," Boston: Houghton, Mifflin Company, 1914, pp. 25–31.

*THOMPSON, JEAN M.: "Water Wonders Every Child Should Know," New York: Grosset & Dunlap, 1907, pp. 97–169.

VAN CLEEF, EUGENE: "The Story of the Weather," New York: D. Appleton-Century Company, Inc., 1929, pp. 38–44.

FINDING THE STREET FIXTURES AND LEARNING THEIR USES

Aims

Orientation in the city environment and greater safety.

Increased social consciousness of group ownership and responsibility.

Suggestions

If the street in front of the school has the usual street fixtures, it is the natural choice for the study. As soon as interest has been aroused, a class trip should be undertaken to locate and study the fixtures.

Find a fire hydrant. Discuss how it is used in case of fire. Discover where the fireman turns on the water, what tool he needs for the purpose, and where the water flows from the hydrant. Discuss how the water gets to the hydrants and where the city gets its water supply. Let the children tell about seeing the fireman turn on the water and allow it to flow down the street. If they cannot guess why he does this, they should be told. Try to decide how close to the fire hydrant cars can be parked without interfering in case of fire. Learn the city ordinance dealing with this matter.

Examine a fire-alarm box. Note the glass to be broken and lever to be pulled down in case of fire. Discuss what the firemen will do when the signal sounds at the fire station. Children should understand that anyone who happens to be near by should turn in the alarm in case of fire. They should also understand that if anyone turned in the alarm for a joke, some other boy's or girl's home might burn while the firemen were answering the false alarm. In most towns firemen are glad to come to the school to demonstrate the fire alarm and answer questions, but this should not take the place of the exploration.

Locate a manhole in the street. Note that there is a shallow well beneath the manhole cover leading down to the sewer which carries away the water from heavy rains. Let the children think out the purpose of the drain holes in the cover. Likewise decide the purpose of the well and why the manhole is so named. Explain the serious accidents that sometimes happen when man-

hole covers become displaced and the importance of reporting any open manholes.

Observe the street lights. Compare them with the lamps in our homes. Note that they are larger and more expensive. Make clear that they belong to all of us and that we should be careful not to break them. Note that no wires to carry the electric current are in evidence, and decide where they must be. Discuss the advantage of underground wiring. Note whether the lights are well arranged to light the whole block.

Note the large wires or cables high above the alley or street and the small boxes or queer-looking fixtures where the wires to the houses leave the main cables. See if the children can guess what these wires carry and why they are placed high above us. They can be told that the transformers cut down the power of the current entering our houses so that it is safer to use. Be sure that they understand why they are warned not to climb these poles. Try to distinguish between power wires and telephone wires.

Observe, discuss, and become familiar with the various street markings and warnings. Include street names and house numbers, school-zone warnings, stop signs, slow signs, parking signs including curb paintings, and signals at railroad crossings. Discuss the meaning of the lights of the semaphore or automatic policeman, and be sure that the children understand that they apply to persons walking as well as to other traffic.

Learn to recognize mailboxes. Mail letters home. Note the collection hours stated on the mailbox. Trace the story of the happenings of the letters until they reach the homes. If a parcel-post box can be found, compare it with a mailbox.

Look for other street fixtures. Talk over what the city has done for us so that we can live together happily and how we can help to make our city better.

Contributing Learnings

When we live close to our neighbors in town or city, we find it better to own many things together. Since these things serve all of us, we ought to understand how to use them wisely. If all persons do so, we help each other and can live together in a safer and happier manner.

We get our water from wells, lakes, or streams, but it comes to us from a city water plant, where it is cleaned and made safe. Trained men test the water. It is delivered to our homes through

underground pipes or water mains. In the street are large faucets or fire hydrants where a long hose can be attached if our homes catch fire. Every few weeks the firemen turn on these street hydrants with a large wrench and let the water flow down the street. This flushes out the water mains and tests out the system to be sure that it is in condition to put out a fire. If we park in front of a fire hydrant, our parking might interfere with the work of fighting a fire and cause some of us to lose our homes. Water cools things below the temperature at which they will burn. It also fills the pores and shuts out the air which is necessary for burning.

In case of fire we must notify the fire department so that they can bring the hose and other fire-fighting apparatus. If they are to save the building, they must be notified as soon as possible. Anyone discovering a fire should break the glass on the fire-alarm box and pull down the lever, after which he should call the fire station by telephone and give them the exact location of the fire. False alarms may take the firemen away when they are needed to save someone's home.

The water from baths, sinks, and lavatories and the sewage from the toilets is carried away in large underground pipes or sewers. Sometimes these sewers become plugged, and it is necessary to clean them out. Storm sewers carry away the water from rains. We have manholes or small wells in the street so that a man can get down to the storm sewer to clean it out. The manholes are fitted with covers. If the cover is left off, we should report it, since bad accidents could result. There are holes in some of the covers to allow the water from heavy rains to drain away down the sewers. Most of the rain water drains into the sewers through gratings close to the curb. With this arrangement our city can be kept clean and dry.

The street lights also should belong to all of us in a well-managed city. There should be enough lights and so placed as to light all of the street. The globes are expensive and easily broken. The wires from the power plant run underground where they are out of the way and where there is no danger that we shall be injured by accidentally touching them.

The large wires overhead, usually in the alleys, bring the electricity for light and power to our homes. They carry enough current for all of our homes and would be very dangerous if they were low down where we might touch them. Where the line

leads to our house there is a transformer which cuts the power down to a safer amount. It is very dangerous to climb the poles to the power wires. When the electrician must climb these poles to repair the wires, the power must first be shut off.

When so many vehicles and persons travel and cross the streets it is necessary to have a system. Each person who is a good citizen will observe these regulations. Failure to do so endangers our lives and those of others.

The mail system is one of the best examples of learning to live together. By properly mailing our letters and packages we can ordinarily depend upon the mailmen to see that they reach the people anywhere in the world to whom we direct them.

We need to learn more about living together. Each must do his part.

References

*CARPENTER, FRANCIS: "Ourselves and Our City," New York: American Book Company, 1928, 291 pp.

*JOHNSON, ELEANOR M.: "Keeping Our City Safe and Clean," Columbus: American Education Press, 1934, 24 pp.

*WALDO, LILLIAN M.: "Safety First for Little Folks," New York: Charles Scribner's Sons, 1933, 165 pp.

LEARNING TO GUESS TEMPERATURE

Aims

Interest in thermometers, temperature records, judging temperature, and various heat-energy phenomena.

Elementary contribution to concepts of phenomena as manifestations of energy changes and of the transformation and conservation of energy.

Ability to read the thermometer and roughly to estimate the temperature. Health protection through carefully checking room temperature.

Suggestions

Learn to read the thermometer. While the centigrade thermometer employs the more logical system, it will probably be better to use the Fahrenheit type as long as weather and other temperature records continue to be expressed in degrees Fahrenheit. Notice how the thermometer works. Heat some water in a tube or other vessel, and find whether it behaves in the same way.

Learn to judge temperature by taking readings of a number of commonly experienced temperatures such as those of a cold day, freezing water, cool cellar, cool drinking water, classroom, furnace room, body, lukewarm water, hot wash water, and boiling water.

Children can watch the oven thermometer at home and find what temperature is used in baking, broiling, etc. Some children who have access to a thermometer at home can find what temperatures are maintained in iceboxes and other refrigerators. Encourage children to investigate and report as many temperature situations as they can.

After recording such a range of temperatures to offer guidance in judging temperature differences, have the children try to guess the temperature before they read the thermometer.

To show that our judgments of temperature are not always good, let some children judge the temperature of lukewarm water after having their hands in very cold water, and others after having their hands in hot water.

Discuss the various uses of the thermometer and the value of temperature control. Try to interest all children in watching the daily temperature changes. Since the temperature is but a

measure of sensible heat, it is well to lead on into a simple discussion of the importances and effects of heat and of its absence (cold).

Tell the children of effects of high room temperatures as shown in the New York ventilation studies. Plan a cooperative check on the temperature of the classroom, and take the necessary steps to correct conditions if they are not good. If a maximum-minimum thermometer can be borrowed, it will be very useful in discovering temperature variations in the classroom and will prove fascinating to the children. Every schoolroom ought to be equipped with this type of thermometer.

Let the children prepare a table of desirable temperatures for our various needs on the basis of their experience and learnings.

Heat a vessel of water, and watch the rise in temperature on a thermometer. Shut off the source of heat, and watch the temperature fall. Feel the heat escaping from the cooling water into the air. See that the children understand that heat is everywhere being taken up from hotter objects and given off to cooler ones, thus changing the temperatures of both. Discuss where heat comes from. See how many examples you can give in which heat energy is being given off and absorbed, with accompanying temperature changes. Discuss how we get rid of extra heat and how we may retain heat to keep the temperatures that we desire.

Contributing Learnings

A thermometer is a tube containing a substance that swells when heated and shrinks when cooled. Mercury is used in most thermometers. We can read the temperature by observing how high the liquid has risen in the tube owing to swelling or expansion. Temperature is one measure of heat.

By observing the thermometer we tell when our rooms are too warm or too cold, when we have fever, when there is danger of our plants being injured, when our water pipes are likely to freeze, when there is enough heat in our ovens to bake best, and many other things about heat that we wish to know. (The concept of latent heat is rather difficult for young children.)

The amount of heat present makes great differences in our lives and in the things going on about us. When there is very little heat, water freezes, and living things may be killed. Our bodies then lose heat rapidly, and it is necessary to wear more clothing

and to be active out-of-doors. A moderate amount of heat is best for most living things (temperatures from 60 to 90°). At these temperatures plants grow rapidly, and the animals are all busy with their affairs. When the temperature of our rooms rises above 70°, many more of us become ill.

High temperatures are not so favorable for most living things but are very useful for cooking, for softening metals so that we can shape them, and for many other purposes.

Heat from the sun is necessary for life here on the earth. Heat is given off in burning (and by many slow oxidations, as in our bodies). Electricity can be changed to heat energy.

Objects lose heat to cooler ones and gain heat from warmer ones.

Some materials conduct heat well. Poor conductors make good insulators to hold heat. By understanding these facts we can keep things at the temperatures that we need for various purposes.

References

*Beauchamp, Wilbur L., Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 29–31.

**Cornell Rural School Leaflet*, Vol. 28, No. 3: Heat, Ithaca, New York: Cornell University, January, 1935.

*Craig, Gerald S., and Agnes Burke: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 89–99.

*——— and Sara E. Baldwin: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 111–118.

*——— and Margaret G. Condry: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 208–213.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 178–187.

*Persing, Ellis C., and Elizabeth K. Peeples: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 101–105.

Reh, Frank: "Water, Air, Sound, Heat, and Health," New York: American Book Company, 1932, pp. 64–71.

*Sullivan, J. W. N.: "How Things Behave," New York: The Macmillan Company, 1932, pp. 29–35.

FINDING AND MAKING OBJECTS THAT FLOAT

Aims

New avenues of play interest and learning.

Elementary experience contributing to realization that natural law prevails.

Suggestions

To begin this activity, which opens a number of avenues of absorbing interest, it is necessary to have only an aquarium or a pan of water. Feel the weight of objects, and try to guess whether they will float, before you toss them on the water.

Try a great variety of objects—various kinds of wood, pieces of metal, tin cans, stones, cork, pieces of glass, open and stoppered bottles, fruits, seeds, clods of earth, etc. Note that a larger portion of some floating objects than of others is immersed in water.

Make a miniature light log (such as basswood or pine) carry a toy figure of a man to represent one of the earliest methods of water travel.

Build a small raft of light sticks, and see how much it will carry.

Procure a pole of some soft wood about two inches in diameter. Cut off sections about ten inches in length, and hollow them out to make dugouts. To simplify the task, bore a series of holes in one side of the section with an inch auger.

Make boats out of half an orange peel and other fruits that are easily hollowed out.

Make a floating dock by nailing short lengths of twigs across two longer ones and tying empty stoppered bottles or sealed tin cans beneath.

Find by trial how much weight the boats and other floating objects will carry without sinking. Partly fill a vial or a small bottle with water, and stopper it. Vary the amount of water until it barely sinks. Increase the air (by decreasing the amount of water) in the vial until it is just light enough to float. Compare with taking a breath of air when we wish to float in water.

Change a toy airplane into a hydroplane by tying long inflated rubber balloons beneath it to serve as pontoons.

Let the children try to explain why some objects float on water while others sink in it. It will be necessary to help them to clarify their thinking by means of further experiences.

Borrow a common balance scale. Exhibit a large quantity of water and a small stone or scrap of metal, and ask which is heavier. Weigh them. Pupils will quickly insist that the comparison is not fair, as you had a larger amount of water than of stone. Let the children try to devise a way of getting equal volumes of stone and water. Try filling a glass with water, inserting the stone, and collecting the water that overflows. Remove the stone, pour the water back into the glass, and repeat, to be sure that all understand that the stone takes up the same amount of space as did the water whose place it took. Place similar small containers on the two arms of the scale, and adjust until it balances. In one container pour the water that overflowed from the glass, and in the other place the stone to see which is heavier.

Let the children try out this method with many substances, comparing their weight with that of an equal volume of water until they comprehend the generalization. Discuss the reason why boats and hollow objects made of heavy metals will float. Decide what determines how heavy a load a boat can carry and how much of floating objects will be above water.

Contributing Learnings

Objects float in water if they are lighter than a quantity of water that would occupy an equal amount of space.

Cork, the lighter woods, many seeds and fruits, and hollow (air-filled) objects float. Metals, stones, earth, and most other objects sink. Seeds containing baby plants often float about on the water and start new plants at its edges. Some objects are light enough to float when first placed in the water, as much of their space is filled with air which is light, but sink after they become water soaked.

The simplest water travel was astride a floating log, a pole or paddle being used to push it along.

By fastening a number of logs together to form a raft, one can ride in greater comfort and haul a load.

A common method of making a dock or boat landing is by floating it on empty oil barrels.

By hollowing out a log or using only the bark, the Indians were able to make a light boat which would carry their weight and still ride lightly over the water.

Most of us are just a little heavier than we would be if made of water. When we expand our chests with a deep breath, we are larger but not much heavier. Now we are lighter than if we were made of water, and we float. In much the same way sailors are able to make submarines rise and sink by varying the amounts of air and water in their compartments.

This is one of nature's ways upon which we can depend. Objects tend to sink or float according to whether or not they are heavier than an equal volume of water. It enabled us to float logs down the rivers to the sawmills and paper mills. It floats seeds to their new homes. It makes travel on water possible, but it also causes many deaths by drowning.

As we load a boat it sinks farther in the water, pushing out of the way a weight of water equal to that of the loaded boat. If we load it until the weight of boat and load is greater than the weight of the water that it would displace when it rests with the edges at the surface of the water, it will sink. It is not safe to load boats with all that they can carry.

References

ADAMS, PETER: "Cork Ships and How to Make Them," New York: E. P. Dutton & Company, Inc., 1928, 112 pp.

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 65–73.

DOWNING, ELIOT R.: "Our Physical World," Chicago: University of Chicago Press, 1924, pp. 116–121.

*NILSSON, KRISTIN: "Water: Its Sources and Uses," Columbus: American Education Press, 1935, pp. 25–28.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book VI: "The Work of Scientists," New York: The Macmillan Company, 1935, pp. 259–280.

*PERSING, ELLIS C., and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 194–201.

POLLAK, JANET: "The Physical World," Chicago: Thomas S. Rockwell Company, 1931, pp. 23–28.

CHANGING THINGS INTO OTHER FORMS

Aims

A beginning toward reducing the apparently chaotic multitude of substances to a basis of organization and understanding.

A very elementary contribution toward the concept that all phenomena are manifestations of energy changes.

Suggestions

Let the children bring in a piece of ice and watch it melt. Change the water to a solid again by placing it out-of-doors. Compare the liquid with the solid. After fixing these states in mind, call for suggestions for changing the water into still another form. Boil the water away into steam. Bring a cold shiny can or other piece of cold metal into the room, and watch the steam (gas) condense into water on the surface of the metal as it cools. Boil some water near a window, and watch the water form again on the cold windowpane. Continue to work with water until the pupils get the idea of the three states of matter. Note during which changes substances take up heat and during which they give it off. Let the children compile a list of the uses that we make of water when it is a solid, a liquid, a gas.

Obtain a few crystals of iodine, a piece of paraffin, or other solids easily liquefied and vaporized. Secure a test tube (pyrex glass for children) from the drugstore if there is none in the school. Heat a few crystals of the iodine gently in the test tube until they melt and vaporize. Keep the tube moving above the flame to avoid breaking. After observing the beautiful gas formed, place the tube outside the window, and watch the gas change back to the solid again as it cools. Try changing the paraffin into other states. Make a mold. Melt paraffin, and pour into the mold.

Let the children discover as many solids, liquids, and gases as possible at home and at school and list the general uses that we make of these three forms of substances.

Observe soft glue, thin jelly, heavy syrup, and other substances that seem to be partly solid, partly liquid.

Contributing Learnings

Substances may be in solid, liquid, or gas form. Some are neither exactly solid nor exactly liquid. Solids are generally

firm, hold their shape well, and do not show much movement. Liquids are less firm and flow. Gases are very light, not firm, move about very readily, and escape easily.

Solids can be changed to liquids, and liquids to gases, by heating them. The heat that they take up causes the change in form. When they lose some of their heat, gases tend to change to liquids. If they lose enough heat, they become solid. Some substances change their form easily; others not so readily. Change in form does not necessarily change the material in the substance, since it can be returned to its other form again.

For many purposes we need solid substances which will hold their shape and position well. For other uses we select the liquids that can move about more readily and fit into any space. We also need the lighter, more freely moving gases.

When we wish to shape a solid to any desired form, we can heat it and let it cool and solidify in a mold of the desired shape.

References

*CRAIG, GERALD S., and SARA E. BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1933, pp. 78–86.

*——— and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 36–47.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 213–219.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book III: "The Outdoor World," Boston: Little, Brown & Company, 1931, pp. 172–174.

FABRE, JEAN HENRI: "The Secret of Everyday Things," New York: D. Appleton-Century Company, Inc., 1920, pp. 230–235.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 173–193.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 163–168.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 106–113.

REH, FRANK: "Water, Air, Sound, Heat, and Health," New York: American Book Company, 1932, pp. 103–109.

*SULLIVAN, J. W. N.: "How Things Behave," New York: The Macmillan Company, 1932, pp. 7–28.

SETTING UP A SIMPLE WEATHER STATION

Aims

Interest in weather, weather recording, and forecasting.

A more scientific attitude regarding the weather and weather forecasting than that which generally prevails among people. Experience making for appreciation of the scientific method and of the need for cooperative study of our problems.

Contribution to the concept that our knowledge is limited and that theories serve to stimulate and direct the search for truth.

Suggestions

Let the children decide what records they will keep and plan the necessary equipment to be made or acquired for the station.

The thermometer will probably have to be purchased, although local concerns sometimes distribute reasonably accurate ones as advertising.

A simple rain gauge can be assembled out of a tall, narrow, straight-sided jar and a wide funnel. Insert the stem of the funnel in the jar as far as possible, and wedge it so that it cannot move. For this purpose a large cork with a hole cut in the center to allow it to fit over the stem of the funnel works well. Prevent any water from entering the top of the jar by sealing with vaseline or cup grease each time the rain gauge is emptied and reassembled. (If a jar and funnel can be found the diameters of which bear a simple ratio, it will be easy for the children to calibrate the rain gauge. For example, if the diameter of the jar is two inches and that of the funnel four inches, a four-inch depth of water in the gauge will mean one inch of rainfall.)

A rough but useful estimate of wind velocity can be made by consulting the table shown on page 274.

Examine a weather vane to get ideas for constructing one. Note that it is an arrow free to turn about a pivot pin through its center of balance and that one end is made broad to catch the wind. Any light wood such as basswood or pine will do. To make the hole large so that the arrow will turn freely it is a good idea first to drive a larger nail and pull it. Then insert the smaller nail and drive it into the end of a stick. Use a drop of oil to reduce friction.

If the activity is carried out by a superior group in the higher intermediate grades, they may even desire a barometer. If so, it is better to borrow or buy one, as skill and patience are required to construct one and calibrate it.

Name	Miles per hour	Effect
Calm	0	Smoke rises vertically; leaves still
Light	1 to 2	Causes smoke to move from the vertical
Gentle	3 to 5	Moves leaves on trees
Fresh	6 to 14	Moves small branches of trees and blows up dust
Brisk	15 to 24	Moves medium-sized branches, makes white caps on lakes
High	25 to 39	Sways trees and breaks small branches
Gale	40 to 59	Breaks small trees down, breaks off large branches
Storm	60 to 79	Prostrates exposed trees and frail houses
Hurricane	80+	Prostrates everything

Adapted from the Beaufort scale.

Set up the station in an open place on the school ground. There is less danger of breakage if a place can be found for it on the lawn than if it were located on the playground.

Set a post in the ground. Fasten the thermometer to the north side of the post at a height at which it can be easily read. Build a little projection out from the post to shade it. Nail the weather-vane stick to the post so that the arrow will be well above it. Nail an arm out from the top of the post, and fasten the rain gauge in an upright position at the end of it. It is well to install an open bucket with vertical sides to collect snow. The snow can then be melted and poured into the rain gauge to measure the precipitation.

Keep records of sunny and cloudy days, wind direction and velocity, temperature, and precipitation. It is well to appoint a weather-bureau recorder or a committee, changing it daily or weekly.

Discover from what direction the wind blows most of the time (prevailing winds). Note the periodic occurrence of clear and unsettled weather. Note which winds seem to bring warm weather, colder weather, stormy weather, and clearing weather. Find out all you can about the U. S. Weather Bureau. Visit the local weather station. Clip the weather records from the daily paper and compare with your own.

Collect prevailing weather notions and lore. Check them against your records to see whether they are true.

Contributing Learnings

Wind is air in motion. Air is a real material as is water or wood, not empty space. When it moves it is able to push and to carry objects with it.

The wind pushes the weather vane around until it presents the least possible surface to the breeze.

When we wish a part of a machine to move readily, it is necessary to prevent it from rubbing hard against other parts. For this purpose we use oil in our machines. We must also be careful that the parts do not fit together too tightly.

Throughout the greater part of the United States most of the winds are from the west. Wind is very important to us. It brings us moisture, cold air from the north, warm air from the south, etc. A brisk west wind usually means clearing weather. Storms are usually followed by a few days of clear weather, after which comes another unsettled period. By noting these changes we can in many cases predict the weather. The U. S. Weather Bureau has stations throughout the country which report conditions daily.

Predicting weather saves many lives which would be lost in storms, gives us time to protect things from freezing during cold waves, and is useful in making our plans.

Moisture evaporates into the air from open water, wet ground, plants, animals, and other sources. Warm air can hold a great deal of moisture. Winds carry moisture, sometimes for very long distances, in the form of water vapor. When air full of moisture is chilled, some of the vapor condenses to water and falls to earth.

By keeping records of the weather over long periods of time we can form some idea of the conditions that occur on the average and how much variation to expect.

We do not understand the causes of the differences in climate which we experience from year to year. There are several theories which are serving to direct the search to learn more about the causes of these changes.

References

Cornell Rural School Leaflet, Vol. 25, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1931.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 97–129.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 93–109.

FREE, E. E., and TRAVIS HOKE: "Weather," New York: Robert M. McBride & Company, 1928, 327 pp.

*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 180–188.

*GORDON, BERTHA F.: "Prove It Yourself," Dansville, New York: F. A. Owen Publishing Company, 1928, pp. 208–210.

MANN, PAUL B., and GEORGE T. HASTINGS: "Out of Doors," New York: Henry Holt and Company, 1932, pp. 315–330.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book VI: "The Work of Scientists," New York: The Macmillan Company, 1935, pp. 29–61.

PAYNE, FRANK OWEN: "One Hundred Lessons in Nature Study," Chicago: Beckley-Cardy Company, pp. 193–199.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 131–147.

*——— and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 197–206.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 239–253.

VAN CLEEF, EUGENE: "The Story of the Weather," New York: D. Appleton-Century Company, Inc., 1929, 274 pp.

MAKING TOY WIND- WATER- AND STEAM-POWER GENERATORS

Aims

An educational play interest.

Extension of the children's concept of energy, its transformation and use.

Realization of the need for conserving exhaustible resources through using other sources which are practically inexhaustible.

Suggestions

It is well to begin with simple paper wind wheels. Use a square sheet of stiff paper. Cut from each corner about two-thirds of the way toward the center. Then bend the alternate points in over the center, and stick a pin through them into the eraser end of a lead pencil. Hold the windmill in the wind, in the breeze from an electric fan, near the air vents, and above radiators.

Try using a windmill made of waxed paper as a water wheel by holding it under the faucet.

Make the windmill operate as a steam turbine by holding it in the steam issuing from a teakettle or coffeepot. An ordinary tin can with a tight lid such as a syrup or coffee can may be used as the boiler to produce the steam by punching a hole in the lid with a nail. By punching four holes evenly spread about the edge of the lid, currents of steam can be directed simultaneously against all blades, as in the large steam turbines. A flask with a short length of glass tubing inserted in a one-hole rubber stopper and drawn out to make a small opening gives a very good jet of steam. An ordinary oil can with a spout works well. Care should be used not to generate steam in it faster than it can escape from the spout.

Paper water wheels and steam turbines soon become limp, and children voice the desire to make more durable ones. They should be encouraged to try out their ideas, the teacher standing ready to discuss their plans with them and give any advice or help needed. A few suggestions should be given to any child who cannot think of an idea that he wishes to try out.

Celluloid may be substituted for paper, and the same design used as in the paper windmills. Celluloid is usually easy to

obtain, since it is used for windows in most automobile curtains. If the celluloid proves too stiff to handle easily, soften it by placing it in hot water. In using celluloid for steam turbines be careful not to bring it too close to the flame, as it burns readily.

Some children may wish to use large flat bottle corks. The outer part of the cork can be cut away in such a manner as to leave thin paddle blades. Another very simple method requiring only a medium-sized cork is to cut perpendicular gashes with a knife at regular intervals about the cork and insert thin blades of celluloid, wood, tin, aluminum, or other material. By cutting slanting parallel gashes and then inserting the blades at an angle some child can make a wheel that operates at right angles to the wind, water, or steam, as do wind gauges and many windmills. Some children will probably wish to make wooden water wheels, one type of which is figured and described on page 340 of "Nature Study and Science for the Intermediate Grades," by Gilbert H. Trafton.

In any of these devices if the power wheel turns on its axle, the movement is uncontrolled and unharnessed. To use the power, the wheel must not slip on its axle but must turn the axle and whatever we belt or gear to it. Some of the wheels devised should, therefore, fit tightly on their axles and be supported in such a way as to show how power is used. Two upright pieces nailed to a heavy block of wood are satisfactory for the supporting frame. Holes should be drilled in the uprights to receive the ends of the axle. Heavy tin or galvanized-iron roofing material can be used for the uprights, if preferred. Allow the axle to project through one upright far enough to fasten a small spool tightly on it. Wrap a small piece of sandpaper around the spool, and fasten it firmly to make a polisher. Operate the water-power wheel under the faucet. Try attaching the spool by means of a string or tape belt to another spool similarly supported on a frame. Use the other spool to wind thread and to do other work requiring very little power. In all of the windmills, water wheels, and steam turbines devised, it is important to reduce friction as much as possible by making the holes large enough so that moving parts will not bind and by using a drop of oil to lubricate each movable contact.

Compare wind, water, and steam sources of power as to availability, dependability, cheapness, exhaustibility, and suitability for various purposes. Find what uses are being made of each of these sources of power in the community.

Contributing Learnings

Wind is capable of doing much work but is a very unsteady source of power and must be supplemented by some other power during periods of calm. It is cheap and is to be regarded as an inexhaustible resource. There is sufficient wind to do work in most parts of the earth. It is suitable for pumping water into tanks and for other operations that do not need to be carried on steadily. It is coming into wider use now, through attaching the wind wheel to an electric generator. The generator charges a battery which supplies a constant current whether or not the wind blows steadily.

Water power is a much steadier source of power but often becomes insufficient during droughts. It, too, is considered an inexhaustible source, although any given waterfall may disappear in time, and the stream become more sluggish. Water power depends upon water being evaporated and later condensed and deposited at higher levels. Almost any rough region with at least moderate rainfall has great possibilities in the way of water-power development, while level regions are almost without natural water power. Unlike wind power, water power can be developed only in certain places where there is a fall in the stream or a rather rapid current. It is now usually converted into electric power and transferred through large power wires. Steam can hardly be considered a source of power, since we must burn a fuel and release its stored energy to heat the water and produce steam. Steam is water changed to gas or vapor. It expands tremendously when it changes to steam, a rough rule being that a cubic inch of water makes a cubic foot of steam. It is this sudden expansion that exerts pressure and gives the steam its great power to do work. Steam affords a steady power and can be developed anywhere where there is water and fuel. It cannot be transferred long distances, since it would condense to water again and lose its power to do work. It is often used to generate electricity and the power used throughout a wide area. Steam is also used for heating and other purposes as well as power. We are rapidly exhausting the coal and oil deposits of the earth. One of the greatest problems facing mankind is to find ways of using wind power, water power, sunshine, fuels from field crops, and other possible inexhaustible sources of energy.

Energy can be changed from one form to another. Wind and water power may be made to do mechanical work directly, such

as grinding grain into flour and feed; or the energy may be changed into electricity; it may be further changed into heat or light. These forms of energy may be changed back to mechanical movement.

References

*CRAIG, GERALD S., and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 291–298.

DOWNING, ELIOT R.: "Our Physical World," Chicago: University of Chicago Press, 1924, pp. 121–127.

*HALL, A. NEELY: "Home Made Toys for Girls and Boys," Boston: Lothrop, Lee & Shephard Company, 1916, pp. 1–8, 38–46.

*LANSING, MARION FLORENCE: "Great Moments in Science," Garden City, New York: Doubleday, Doran & Company, Inc., 1926, pp. 53–67.

*PERSING, ELLIS C., and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 169–184.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 257–259, 339–341.

FINDING OF WHAT THINGS ARE MADE

Aims

Interest in discovering what things are made of and in the use of materials in construction activities.

Contribution to the concept that the vast use made of a relatively few discoveries demonstrates the importance of research.

Suggestions

Examination of almost any object will serve to bring up this problem and to launch the project.

Let the children examine objects at school and home and try to account for the selection of the material or materials used in their construction. If any buildings are in process of construction, it will prove interesting to visit them.

Compare the different materials as to strength, weight, transparency, ability to withstand heat, rigidity, hardness, durability, etc.

Compile lists of the uses that we make of glass, wood, metals, rubber, etc.

Discuss what the use of these materials has meant to us. Discuss some of the basic discoveries that made it possible for us to have so many useful objects and to live as we now do.

Contributing Learnings

Wood is one of the commonest materials. It has been the most used material because it has been abundant and cheap. Our supply of wood is running short. Wood is easy to saw, plane, and nail. It has beautiful grain. It does not rust, but it decays, and insects attack it. Some of it is made into paper. Wood burns readily and is one of our great fire hazards. We could grow enough trees to supply all of the lumber that we need.

Glass is used for windows, aquariums, tests tubes, and many other objects because it allows the light to pass through readily. This also makes it good for mirrors. It will not rust or burn, but it is rather easily broken. It is a very clean-appearing material for dishes and table tops.

Most rubber is not so rigid as wood, glass, and metals. Since it can be stretched and compressed, it is used for balls, tires,

engine mountings, elastics, and many other purposes. It is used for overshoes and raincoats because water will not pass through it readily.

Most metals possess strength and hardness. They can be drawn out into wire or hammered into sheets when heated. By melting them and letting them cool in molds, we can form them into any desired shapes. Some are very heavy and therefore useful where we need weight to hold objects in place and prevent shaking. Metals, being hard, can be used to cut many other materials. Iron is the commonest and most generally useful metal at present. It has the disadvantage of rusting if exposed to the air. Iron is cheap, but some metals are very expensive. Metals are used for so many purposes that one could hardly list all of them.

Out of these materials we build our homes, automobiles, trains, and most of the objects that we use. If we did not know how to use them, we should be living as the savages lived. But there must be many more uses for them which we have not yet discovered. Every family should have the advantages of all of the articles made of these materials that they need.

References

*Carpenter, Frank G., and Frances Carpenter: "The Houses We Live In," New York: American Book Company, 1926, 204 pp.

**Cornell Rural School Leaflet*, Vol. 28, No. 4: Made of Earth, Ithaca, New York: Cornell University, March, 1935.

Mersereau, Samuel Foster: "Materials of Industry," New York: McGraw-Hill Book Company, Inc., 1931, 478 pp.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 41–359.

*——— and ———: "Nature and Science Readers," Book VI: "The Work of Scientists," New York: The Macmillan Company, 1935, pp. 305–378.

*Payne, George E., Henry R. Barrows, and Louis J. Schmerber: "Elementary Science Readers," Book III, Boston: Benjamin H. Sanborn & Company, 1928, pp. 64–90.

*Persing, Ellis C., and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp 261–268.

Rush, Charles E., and Amy Winslow: "Modern Aladdins and Their Magic," Boston: Little, Brown and Company, 1926, 318 pp.

COLLECTING COMMON METALS AND STUDYING THEIR USES

Aims

Greater interest in the industrial environment.

Some realization of the great changes in our ways of living brought about by the extensive use of metals.

Appreciation of the great value to man of our metal resources and the need to conserve them.

A more critical attitude in purchasing skates, knives, and other articles of metal.

Suggestions

Scraps of iron, tin, aluminum, copper, lead, zinc, and nickel can be readily supplied by members of the class, many of whom will keenly enjoy searching for such things. The collection is also likely to contain chromium, cobalt, a little mercury, bits of gold, silver, and other metals. All of these will not be the pure metal. Some will be alloys, or combinations of two or more metals.

Test the metals in various ways. Try to bend them. Attempt to cut them with a sharp knife. Pound them with a small hammer to determine whether they can be easily flattened out into thin sheets. Heat them, and strike them with the hammer.

Place them on a radiator or warm stove along with other objects to see how rapidly they conduct heat and become heated through. Try to melt them. (Mercury is liquid at ordinary temperatures.)

Weigh the pieces to discover whether they are heavy or light in proportion to their size. If a graduated glass is available, partly fill it with water, and find the volume of each piece of metal by placing it in the graduate and noticing how much it raises the water level. Compare the weight of each with its volume to discover how they compare in weight.

Place the scraps of metal in a wet place to discover which will rust.

Compare the metals in various respects with rock, wood, and other materials, and consider their possible uses.

Examine tools, implements, machinery, utensils, and other objects made entirely or in part of metals, and try to discover the reasons for the uses of the different metals. Question hardware dealers, machine-shop men, jewelers, and other metalworkers.

Read about the uses of the different metals, and make lists of them.

It is likely that various alloys will be collected. Some of the commonest of these are brass (copper and zinc), solder (lead and tin), bronze (copper, tin, zinc, and lead), silver coin (silver and copper), five-cent piece (nickel and copper), one-cent piece (copper, tin, and zinc), gold coin (gold and copper), and steel (iron together with carbon, chromium, manganese, or other substances). Consider the reasons for using alloys, such as cheapness, hardness, and strength.

Secure a sample of iron ore or other ore, and find by reading or questioning how the metal is separated from the ore.

Let the children find from their reading something of the history of the use of metals.

Contributing Learnings

Many metals can be pressed into thin sheets or drawn out into wires which are nevertheless hard, strong, and tough. They withstand ordinary temperatures including cooking temperatures, yet they can be melted at high temperatures and shaped into any desired form.

Some metals carry electric current with little resistance; others possessing moderate resistance make good heating elements.

Some metals are heavy and suitable for large stationary objects, while others are light and important for such uses as aircraft.

Iron rusts rather readily, while nickel, aluminum, and some other metals do not.

There are many kinds of alloys—combinations of two or more metals. They are used for various purposes—in some cases because they are superior, and in others only because they are cheaper than the pure metal. Bronze is an alloy of copper and tin; brass, an alloy of copper and zinc. Iron is combined with many other substances to form various kinds of steel, which, on account of its toughness, hardness, and ability to take a fine edge, is one of our most valuable materials.

Because it is a liquid at ordinary temperatures and very heavy, mercury is used in thermometers.

Most metals are not obtained in a pure state but must be separated from their ores by smelting.

So far as we know, gold was the first metal known to the ancients. Several thousand years ago, people came to use cop-

per for implements by hammering and, later, casting it. Bronze was probably discovered accidentally by heating ore that contained veins of both tin and copper. Bronze proved better than copper for many purposes and became widely used. It was much later, perhaps 3,000 years ago, that iron came into use.

The age of copper and bronze followed the stone age. For a long time the metal instruments were shaped like the stone ones. It was hard for man to see that new knowledge made it possible to do things differently. Gradually metalworking developed. The age of iron followed, but the use of iron for new purposes came gradually. It was not until about two centuries ago that the industrial age developed. Even today, in some back-country communities, people are living somewhat as they did before the use of metals in a great range of complicated machinery made our machine age.

References

*CARPENTER, FRANK G., and FRANCES CARPENTER: "The Houses We Live In," New York: American Book Company, 1926, pp. 84–109.

FABRE, JEAN HENRI: "The Secret of Everyday Things," New York: D. Appleton-Century Company, Inc., 1920, pp. 148–158.

MERSEREAU, SAMUEL FOSTER: "Materials of Industry," New York: McGraw-Hill Book Company, Inc., 1931, pp. 305–428.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book VI: "The Work of Scientists," New York: The Macmillan Company, 1935, pp. 335–359.

*PAYNE, GEORGE E., HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book III, Boston: Benjamin H. Sanborn & Company, 1928, pp. 45–73.

*PETERSHAM, MAUD, and MISKA PETERSHAM: "The Story Book of Iron and Steel," Philadelphia: John C. Winston Company, 1935, 32 pp.

RUSH, CHARLES E., and AMY WINSLOW: "Modern Aladdins and Their Magic," Boston: Little, Brown & Company, 1926, pp. 73–80.

WILHELM, DONALD: "The Book of Metals," New York: Harper & Brothers, 1932, 341 pp.

WIRING SIMPLE ELECTRIC CIRCUITS

Aims

Realization that natural laws prevail in the field of electrical phenomena, so often considered miraculous. A better concept of energy and energy transformations. Realization that our knowledge is limited.

A means of finding satisfaction in educational play.

Ability to care for dry cells and to select wires for particular uses. Greater safety through understanding some of the dangers from high-voltage currents.

Suggestions

As a source of power, use dry cells or an ordinary automobile or radio battery. Dry cells are best, as there is no danger of injuring clothing or receiving acid burns. It is not advisable for elementary children to play with the 110-volt circuit. Searchlight batteries can be used. They possess the disadvantages of small capacity and lack of binding posts for attaching wires.

Attach one end of a short piece of wire to one of the binding posts of the dry cell, and scrape the other end rapidly over the other binding post to see whether there is a spark indicating that the dry cell is in good condition. Never leave the dry cell short-circuited in this manner with very little resistance in the circuit, as the cell would be exhausted in a short time.

Let the children bring to school samples of any wire that they can find. Try shorting the various types of wire across the dry cell terminals momentarily to see whether they heat. Use six-inch lengths of iron and copper wire of various sizes to find which heat most.

Short a piece of very fine wire directly across the binding posts and note that the wire glows. As heat and light are usually needed at a distance from the source of power, let the children devise a way to get the wire to light up a few feet from the dry cell. Use large lead wires from the dry cell with a very short length of fine iron wire inserted in the circuit wherever light and heat are desired. It may be necessary to use more than one dry cell. Connect the dry cells in series, that is, a center post of one dry cell to the outside post of the other.

Replace the short length of fine iron wire in the circuit with a lamp from a small search light, touching one wire to the center of the base and the other to the side. Try inserting a toy motor in the circuit.

Secure a doorbell, and insert it in the circuit. The pupils will be very interested in installing the doorbell permanently where you desire it in the schoolroom. Insert a push button in the circuit at the front door. See that all wiring is neatly done and the wires securely fastened in place. Use insulated copper wire about size 14.

Tear an old dry cell apart, or cut it in two with a saw to find how it is constructed.

Formulate all of the facts and principles learned.

Contributing Learnings

In a dry cell, chemical action generates electric current between the plates or electrodes. The outer electrode of the dry cell is of zinc; the inner one, of carbon. The solution attacks the zinc, causing a current to flow if the two binding posts are connected with a good conductor, thus closing the circuit. When the circuit is broken, the current ceases to flow.

Metals are generally good conductors. Copper is a much better conductor than iron. For this reason we use copper wire to carry current with little loss from resistance. On the other hand, we use iron or other high-resistance wire to produce heat and light. Fine wire offers more resistance to the electric current than does coarse wire. The longer the wire the greater the resistance and the more dry cells will be needed to push the current through the circuit. A lamp contains fine wire which offers high resistance and is heated until it glows.

The electrical pressure is known as voltage. Each dry cell affords one and one-half volts pressure. The amount of current (amperes) that it can force through a circuit depends upon the resistance in the circuit. It tells on the electric lamps and other devices how many volts are needed to force sufficient current through them. They often show how much current they draw and how much resistance (ohms) they offer.

When dry cells are connected in series (carbon to zinc), we get their combined voltage. A "short" or short circuit is a direct connection between the electrodes with very little resistance in the

circuit. It soon runs a dry cell or battery down and overheats the wires, often causing fires.

When we use one pair of electrodes, it is known as a cell. More than one cell is a battery.

We do not understand many things about electricity. It follows definite laws, however, and we can depend upon what we have learned concerning it.

One form of energy can be changed to another form, as chemical to electrical to heat and light.

High voltages kill many people. We should be careful to observe caution signs about machinery and never to touch large wires which might be carrying high-voltage currents. The substances formed around the corroded terminals of wet batteries are extremely poisonous. The acids used in these batteries can cause severe burns and will eat holes in clothing.

References

*CRAIG, GERALD S., and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 277–290.

*——— and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 292–296.

*KELLOR, KATHERINE L.: "Working with Electricity," New York: The Macmillan Company, 1931, pp. 1–23.

MEISTER, MORRIS: "Magnetism and Electricity," New York: Charles Scribner's Sons, 1930, pp. 31–55.

*MORGAN, ALFRED: "A First Electrical Book for Boys," New York: Charles Scribner's Sons, 1935, pp. 82–98.

PARKER, BERTHA MORRIS: "The Book of Electricity," Boston: Houghton Mifflin Company, 1928, pp. 21–57.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 157–177.

*PERSING, ELLIS C., and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI. New York: D. Appleton-Century Company, Inc., 1930, pp. 159–164.

REH, FRANK: "Science Related to Life," Book III: "Magnetism, Electricity"; Book IV: "Light, Forces, and Machines," New York: American Book Company, 1933, pp. 51–59, 83–95.

EXPERIMENTING WITH THE POWERS OF MAGNET AND COMPASS

Aims

An educational play interest.

An elementary knowledge of the principles of magnetism. Experience contributing to the realization that the manifold uses that have been made of a few basic discoveries demonstrates the great importance to mankind of scientific research.

Suggestions

Some of the pupils are likely to have magnets at home which they can bring to school for this study. Magnets sold at the five- and ten-cent stores are usually satisfactory for this purpose, although it is well to test them on a piece of iron or steel before purchasing. Try also to secure a piece of magnetic ore commonly called loadstone. Try out a large number of materials such as paper, glass, wood, rubber, cloth, and metals to discover which the magnet will attract. Pupils will gladly bring scraps of the commoner metals. Test and classify the metals into those strongly magnetic, such as iron and nickel, and those little or apparently not at all magnetic.

Discover how far a small piece of iron or steel can be attracted to the magnet. See if it can be attracted in any direction by the magnet. This magnetic field can be demonstrated by placing a sheet of glass or paper over a magnet and scattering iron filings on the surface of the glass. Discover whether or not the center of the magnet attracts as do the ends.

See how many tacks or small nails can be made to cling to the magnet. Find out also how many will cling suspended end to end from the magnet, and discuss what this shows.

Discover whether the nails or tacks retain their magnetism after being pulled away from the magnet.

Magnetize a nail or pocket knife by rubbing it against the magnet. Then see if you can make it lose its magnetism by striking it, heating it, or otherwise.

Magnetize a piece of soft iron and one of hard steel, and see which remains a magnet longer.

See if a magnet can exert its effect through glass, paper, water, cloth, and thin strips of wood.

Let children devise ways to control a fleet of toy boats by the use of magnets. They can make the boats by folding paper. Wax paper which will not absorb water is best. If pupils have carried out the preceding suggestions, they will understand that the boats can be attracted in any direction if they contain magnets. Accordingly, a needle should be magnetized and laid in each boat. To magnetize a needle rub its eye against one pole of the magnet and the point against the other pole.

Discover by trial that the eyes and points of the needles are attracted by the poles of the large magnet against which they were rubbed and repelled by the other pole. This will be especially clear if the needles are suspended by threads attached to their mid-points, and the poles of the large magnet brought near them. Bring another magnetized needle near the suspended needle, or place two such needles side by side on the table, and observe that two eyes or two points repel each other, while the eye of one is attracted to the point of the other.

The small paper boats can be floated on water in any large shallow pan or tray. Observe the positions that they assume as each magnetized needle acts as a compass. Note that some of the boats have a tendency to collide and cling together whenever they approach each other. See whether these boats contain needle magnets arranged with unlike poles. Other boats will be seen to repel each other. See how their magnets are arranged.

Now maneuver the fleet by holding the large magnet above it. Try each pole of the large magnet, and study and explain the behavior of the boats. Try to keep the boats apart and moving steadily in the same direction.

Magnetized needles may likewise be placed in toy celluloid water animals, and their movements guided by a large magnet.

It is likely that some of the pupils will have small compasses. They are inexpensive items which can be purchased locally and should be a part of the elementary science equipment of the school.

Note that one arm of the compass points north and is called the north-seeking pole or simply the north pole.

Bring the compass near some other magnet. Try it in various parts of the room near steel-reenforced walls, metal desks, and other steel objects. Bring it near an electric-light cord or other

wire. Then turn on the current. Note that a current flowing through a wire makes it a magnet.

Turn the compass on edge, and note the dip of the needle as it is influenced by the magnetic force of the earth.

After learning that a compass is only a magnet balanced in such a way that it can turn about in response to the attraction of the earth magnet, the pupils should devise ways of using a straight bar magnet as a compass. Magnetize a large needle by rubbing it against a magnet, and suspend it with a thread attached to its center. Magnetize another needle, and lay it on a bottle cork floating on water. Mark the north poles in some manner.

Try to steer your way due north through a park by using a compass and picking out an object in a direct line with the needle a short distance ahead. Upon arriving at this object, check your course by sighting back over the south pole of the magnet. Continue in this way, checking your course frequently. Then sight back to the starting point, or verify your course by any north-south roads or signs. Discuss the use made of the compass by sailors, lumber cruisers, hunters, and other persons who travel unmarked regions. If any such persons are available, get them to tell of their experiences in using a compass.

Hold a treasure hunt in the park in which the treasure is to be located by use of the compass. Each treasure seeker should have a compass and written instructions to follow, calling for change of direction several times. The places where change of direction is to be made should be chosen with reference to distinctive trees, rocks, or other objects. Otherwise, it is necessary to mark these spots or to measure distances.

Contributing Learnings

In carrying out this project, pupils come to understand that iron, nickel, and some of their compounds are highly magnetic, while most of the metals are not. They will also learn that the poles of a magnet are the regions of great attraction and that about them exists a magnetic field. Any substance capable of being easily magnetized becomes a magnet when brought into this field. If it touches a pole of the magnet, it becomes highly magnetized and, in turn, is capable of attracting objects. Hard steel retains much of this magnetism, while soft iron loses nearly all of it on being removed from the magnet. Jarring a magnet or heating it causes it to lose much of its magnetism.

Magnets exert their effect through nonmagnetic materials.

Unlike poles of magnets attract each other; like poles repel. Magnets free to move arrange themselves with unlike poles together.

The earth contains great deposits of magnetic ore in the North and acts as a huge magnet. A small floating or suspended magnet turns about until its poles point north and south, becoming a compass. The compass has been used by millions of travelers on land and sea to guide them. Steel and iron structures, wires carrying electric current, and local deposits of magnetic ores naturally prevent the compass from pointing northward. Pupils will be able to understand how the traveler is able to tell when his compass is "off" by sighting back over the needle to check his direction, and how the compass aids in locating ore deposits. They will also appreciate why it is wise never to enter a wild region without a compass and a general map.

The magnetism principle is used in loading scrap iron, lifting heavy steel beams, in doorbells, automatic telephone systems, telegraphs, in extracting small steel fragments from the eye, and for many other purposes. It is used in many lottery devices to "spoil the aim" of the player by attracting the ring or ball from its mark.

References

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 132–140.

*——— and SARA E. BALDWIN: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 285–300.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 111–129.

*GORDON, BERTHA F.: "Prove It Yourself," Dansville, New York: F. A. Owen Publishing Company, 1928, pp. 29–40, 58–61.

*KELLOR, KATHERINE L.: "Working with Electricity," New York: The Macmillan Company, 1931, pp. 24–44.

MEISTER, MORRIS: "Magnetism and Electricity," New York: Charles Scribner's Sons, 1930, pp. 1–19.

*MORGAN, ALFRED: "A First Electrical Book for Boys," New York: Charles Scribner's Sons, 1935, pp. 24–38.

PARKER, BERTHA MORRIS: "The Book of Electricity," Boston: Houghton Mifflin Company, 1928, pp. 88–122.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 290–299.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 135–140.

*PHILBRICK, METTA G.: "Magnetism and Electricity," Columbus: American Education Press, 1935, 35 pp.

REH, FRANK: "Science Related to Life," Book III: "Magnetism, Electricity"; Book IV: "Light, Forces, and Machines," New York: American Book Company, 1933, pp. 9–23.

MAKING AN ELECTROMAGNET

Aims

An educational play interest. Greater interest in the industrial environment.

Experience contributing to concepts of the transfer of energy, the dependability of natural law, and the importance of the electromagnetic principle to mankind.

Suggestions

Before undertaking this project, pupils should have carried out the two preceding activities. They will have learned that when an electric current flows through a wire, the wire becomes a magnet, as shown by its effect on the compass. They will also have found that a piece of iron or steel placed within the field of a magnet becomes magnetized. They are therefore prepared to understand that if they pass a current through a coil of wire wound about a steel or iron core, the wire becomes a magnet and in turn magnetizes the core.

It is a very simple matter to employ these principles and make an electromagnet. A bolt makes a good core. It is necessary only to wind a foot or two of insulated copper wire around the bolt, leaving a few inches of wire at each end of the coil to make contact with the binding posts of a dry cell. The wire ought not be fine, as resistance would reduce the current flow and consequently the magnetism. Number 18 wire, which should be a part of the school equipment, is quite satisfactory.

Fasten one end of the coil to one of the binding posts of the dry cell, and touch the other end to the other post when you are ready to test the magnet. See how heavy a load the magnet will pick up. Note that this electromagnet drops its load as soon as the circuit is broken, and work out the explanation. Devise some sort of switch to turn on the current, and use the electromagnet to transfer screws, nails, tacks, or other objects into a toy truck or railroad car by breaking the circuit just as the electromagnet with its load is directly over it. Let the children experiment to get the strongest magnet possible with the voltage used by varying the number of turns of wire.

Use a piece of steel for the core, and note that steel retains the magnetism after the current ceases to flow, whereas a soft iron core is a magnet only when the current is flowing. Discover which is the north and which the south pole of the steel magnet that you have made. Mark them, and keep the core for a permanent magnet.

Contributing Learnings

When a current flows through a coil of wire, the wire becomes a magnet. Any substance within its field capable of being magnetized also becomes a magnet. If we use a soft iron core, the magnetism is lost when the current ceases to flow.

We can strengthen the magnet within limits by adding more turns of wire or by using greater voltage. Fine wire has the advantage that we can get more turns close to the core but the disadvantage of greater resistance. If we add too many turns of wire without increasing the voltage of our battery, the resistance becomes so great that little current flows, and our electromagnet is weak. We can tell by trying various numbers of turns of wire how to get the strongest electromagnet. The engineer can calculate these things, as voltage, current, and resistance work according to laws.

Electromagnets are used in many of our modern devices. (See the statement of contributing learnings in the next activity for a partial list.)

References

*Craig, Gerald S., and Margaret G. Condry: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 130–135.

Meister, Morris: "Magnetism and Electricity," New York: Charles Scribner's Sons, 1930, pp. 20–30.

*Morgan, Alfred: "A First Electrical Book for Boys," New York: Charles Scribner's Sons, 1935, pp. 52–64.

Parker, Bertha Morris: "The Book of Electricity," Boston: Houghton Mifflin Company, 1928, pp. 123–137.

*Persing, Ellis C., and John A. Hollinger: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 159–164.

Reh, Frank: "Science Related to Life," Book III: "Magnetism, Electricity"; Book IV: "Light, Forces, and Machines," New York: American Book Company, 1933, pp. 24–32.

DISCOVERING HOW OUR ELECTRIC DEVICES WORK

Aims

A sense of adjustment through reduction of the confusing electrical environment to a few principles.

Realization that a scientific principle may serve as the basis for many inventions and practices to lighten labor and enrich life.

A growing realization that the discoveries of science make possible an economy of abundance rather than of scarcity and call for social attitudes.

Suggestions

Before undertaking this survey, the pupils should have wired a circuit to produce heat and light and made an electromagnet. In carrying out the survey, examine as many simple electric devices as possible to discover whether they employ either of these principles. It is neither necessary nor wise to attempt detailed explanations of these devices at this time. For example, the explanation of the operation of electric motors is difficult for intermediate-grade pupils, while it is comparatively easy to discover that they work on the electromagnet principle.

To launch the project, it is well to provide a few electric devices which the class as a whole may analyze for the principle employed. Such devices as an electric toaster, a small electric heater, or an electric lamp afford an easy introduction to the first of these principles, as the resistance units are exposed and may be clearly seen. To make the principle clearer, they should be connected to the light circuit, and the current turned on. An ordinary doorbell, buzzer, or toy electric motor will offer an opportunity for the discovery of the application of the electromagnet principle. The doorbell and buzzer electromagnets are clearly exposed by lifting off the cap that covers them. These electromagnets sufficiently resemble those which the pupils will have made so that they are easily recognized. To observe their action, connect the doorbell with a dry cell, and observe how the electromagnet pulls the clapper arm over against the bell. If pupils ask why the clapper continues to strike the bell, they can be shown (if they cannot trace the circuit and discover) that the clapper arm is a part of the electric circuit.

When it is pulled by the electromagnet away from its contact, the circuit is broken, just as if a wire had been disconnected. The current then ceases to flow; the magnet no longer attracts the clapper arm, which springs back completing the circuit again; and the process is repeated. The electromagnets are visible in most toy electric motors. To see the electromagnets run the toy motor, connect it to a battery of dry cells or through a transformer to the light circuit. Be sure not to connect the motor to the light circuit without a transformer unless it bears the mark "110 V.," such as appears on ordinary electric lamps, indicating that it is intended for direct use on the 110-volt light circuit.

After analyzing a few devices in this manner and discovering that they are only clever applications of two familiar principles, surveys should be made of electrical devices at home. Make arrangements with the manager of an electric store, and visit it to inspect the various appliances. Secure complete sets of the advertising matter in this field, and try to analyze each device from the printed description. In this way a large number of devices can be studied, some of them not usually carried in stock by smaller stores.

Compare the advantages and disadvantages of the use of these devices with other methods for accomplishing the same purposes.

Contributing Learnings

When an electric current flows through a material that offers considerable resistance, heat is produced. The heating element is usually in the form of a very thin strip or fine wire offering high electrical resistance. The smaller the size (cross section) of the wire the greater the resistance. This principle is used in electric ranges, heaters, irons, ironing machines, curling irons, toasters, percolators, chafing dishes, waffle irons, grills, egg cookers, hot plates, shaving mugs, heating pads, dryers, lamps, and many other devices. In the lamps the element is heated to such a high temperature that it glows and gives off light.

When an electric current flows through a wire, the wire becomes a magnet with a magnetic field about it. The magnetic field is strengthened by inserting an iron core in the coil of wire, as the core also becomes a magnet. Such electromagnets are used to attract objects and to produce motion. The electromagnet loses its magnetism when the current ceases to flow. Thus by arranging the electromagnet in the circuit so that it will attract a bar

and break the circuit, we get interrupted action. By adding a spring to pull the bar back in place and complete the circuit after the magnetism is lost, we get intermittent or vibrating action, as in bells, buzzers, telegraph instruments, and induction coils. By changing the direction of the current through the coil of wire we change the poles of the magnet at the proper time to secure whirling motion in our electric motors. The motors are used to run sweepers and cleaners, washing machines, fans, sewing machines, food mixers, automobile starters, machines in shops, and a host of other useful devices.

In devices that work on the electromagnet principle we use wire that is a good conductor, while in devices to provide heat or light we use resistance wire.

The discovery of a general law or principle is an occasion for great rejoicing, although we seldom realize how great the discovery is until inventors and other practical workers have used the principle as a basis for a host of labor-saving and life-enriching devices. Great discoveries are seldom made by any one man but come as a result of the labors of many workers, each adding a little until the principle is apparent. These great discoveries ought to belong to all of us. They should be used for the greatest service to all mankind rather than for the building of fortunes out of profits secured by maintaining high prices which limit their wide usage.

References

*Craig, Gerald S., and Goldie M. Johnson: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 285–336.

*Kellor, Katherine L.: "Working with Electricity," New York: The Macmillan Company, 1931, pp. 1–70.

Lacey, Ida Belle: "Light Then and Now," New York: The Macmillan Company, 1930, pp. 121–203.

*Morgan, Alfred: "A First Electrical Book for Boys," New York: Charles Scribner's Sons, 1935, 209 pp.

*Parker, Bertha Morris: "The Book of Electricity," Boston: Houghton Mifflin Company, 1928, 314 pp.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 157–177.

*Persing, Ellis C., and John A. Hollinger: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 159–188.

*Philbrick, Metta G.: "Magnetism and Electricity," Columbus: American Education Press, 1935, 35 pp.

HOLDING GLIDER AND AIRPLANE RACES

Aims

An educational play interest and a greater interest in observing and reading about air travel.

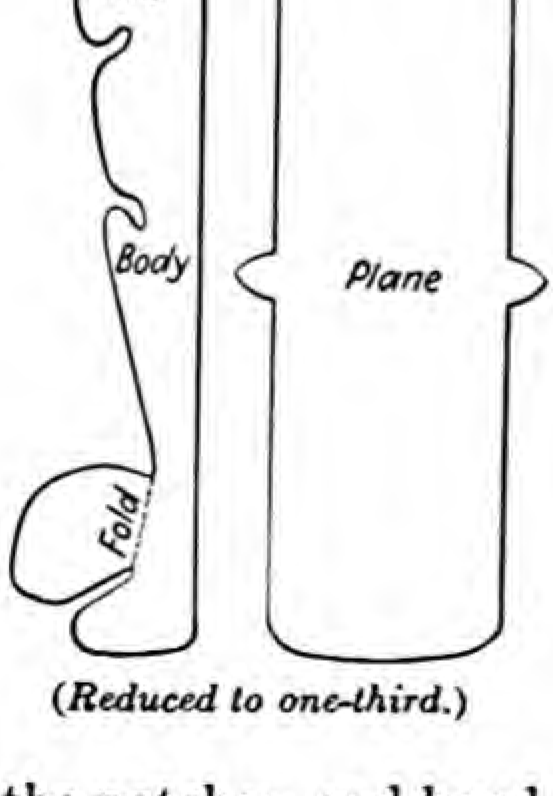
Realization that flying is not miraculous but only a matter of employing certain principles of natural law.

A social interest in the use of discovery and the problems of air travel.

Suggestions

It is better to begin with gliders, later adding propellers and a source of power. It is well to make a few cardboard gliders at the time when the project is planned and discussed. Their construction is very simple. At the same time they permit of almost endless variation and experimentation. One type of construction is illustrated below. (See Collins, "The Boys' Book of Aeroplanes," pages 31–34, for figures and direction for making other types of gliders.)

Cut out the plane. Fold a piece of heavy paper or tough cardboard, and cut out the body.



(Reduced to one-third.)

Insert the plane in the notches, and bend the rear guide planes outward along the line marked "Fold." Weight the front end

with paper clips or other objects until the glider sails smoothly forward when thrown with an overhand motion.

After a few types of gliders have been constructed under the guidance of the teacher, the pupils will construct many others independently. The next step is to experiment by varying the construction until long graceful flights are obtained.

Vary the location of the main plane and its angle or tilt. Try bending the wings upward. Bend the plane into a convex or concave surface. Experiment with various sizes and shapes of planes. Alter the size and angle of the guide planes. Find by trial the right amount of weight to add to the front of the plane. Excellent wooden gliders, the planes of which can be adjusted forward or backward on the body, can be purchased at the ten-cent store.

At this stage, gliders of paper, cardboard, wood, and even metal may be constructed and perfected for the tournament. Some of these may be of the slingshot type to be launched with rubber bands. Study the gliders to discover what keeps them afloat and why it is necessary to construct them as we do.

The gliders entered in the tournament may compete in three classes.

Class I: Hand-thrown paper and cardboard gliders.

Class II: Hand-thrown wood and metal gliders.

Class III: Slingshot gliders.

They should be thrown from behind a line and start at equal heights. Two types of winners may be picked in each class: (1) the glider executing the longest flight and (2) the glider executing the most graceful flight.

The study of gliders is almost certain to result in requests for airplane construction and tournaments. If this part of the project is not carried out by all members of the class, a sufficient number can usually be found who are eager to undertake it. (On pages 99–100 of "The American Boy's Work Shop," by Kelland, instructions for adding a simple propeller and rubber-strand motor are given. See also Collins' "The Boys' Book of Model Aeroplanes" and the files of popular scientific magazines for suggestions.) Airplanes with rubber-band motors can be purchased at the ten-cent stores and toyshops to serve as models. The chief problem in constructing these toy airplanes is in securing materials that will be light and strong enough. Balsa wood can be purchased. It is light but not very durable. Basswood

sawed very thin will do for planes. The airplanes may be constructed at home and brought to school for trial flights and, later, for the tournament.

Compare the toy airplanes with commercial ones in principle of operation, nature of accidents, and flight failures. Discuss the achievements and problems of air travel.

Contributing Learnings

Balloons and airships contain very light gases and weigh less than an equal volume of air. They rise when released.

Airplanes are much heavier than air. If they could be made lighter with sufficient strength, the problem would be simpler. There is a constant search going on for lighter material which will have sufficient strength.

Solid substances offer greater resistance to movement than liquids; and liquids, greater than gases. Air is a mixture of gases. We know that it offers resistance when we try to pull an open umbrella suddenly toward us. When pushed slowly, it is easily moved out of the way. When struck suddenly, it seems almost as if it were solid.

When the rapidly whirling propeller of the airplane strikes the air, the air resists being moved readily, and the airplane is pushed forward. In like manner, the wings of the plane, as it is pushed rapidly forward by the propeller, strike the resisting air and cause the airplane gradually to climb on it. Other smaller planes working on the same principle enable the airplane to elevate the tail or to bank in either direction. Airplanes cannot fly at low speeds, since the air would not offer sufficient resistance.

Airplanes also require large starting and landing fields. If airplanes can be made to rise vertically by horizontal whirling propellers or other means, it will be possible to rise from the roofs of buildings or small lots and likewise to land on them. Hopeful experimental flights have been made with such gyroplanes.

The commercial airplane differs from the toy one in having gasoline-burning motors to drive the propeller. This means carrying large supplies of fuel for long flights. Many accidents occur when the fuel supply is exhausted where there is no suitable landing field. As with automobile motors, many difficulties develop, with the added danger of being off the earth where gravity can pull the plane to earth with terrific speed. Another great danger lies in the storms and air pockets. A modern air-

plane has many devices for flying "blind." We cannot control the great air movements and storms on the earth. We can only predict them and be on our guard with every known device of science.

Experiments with oil-burning engines seem very promising. Planes are becoming cheaper and, therefore, of greater service.

The airplane was invented in this country, but we have fallen behind many other countries in our government air service, as shown when our fliers attempted to carry the mails.

Some remarkable flights have been made with gliders, but long-distance flights cannot be made by them.

References

*CRAIG, GERALD S., and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 369–388.

HAMBURG, MERRILL: "Beginning to Fly," Boston: Houghton Mifflin Company, 1928, 197 pp.

HARNEY, LAURA B., and ROLAND H. SPAULDING: "The Skycraft Book," Boston: D. C. Heath & Company, 1932, 338 pp.

OTT, JOSEPH S.: "Model Airplanes; Building and Flying," Chicago: The Goodheart-Wilcox Co., 1931.

*PETERSHAM, MAUD, and MISKA PETERSHAM: "The Story Book of Wheels, Ships, Trains, and Aircraft," Philadelphia: John C. Winston Company, 358 pp.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 171–174.

TRACING THE ACTIVITIES OF ANIMALS BY THEIR TRACKS IN THE SNOW

Aims

Interest in the activities of animals in winter. Enjoyment of outdoor observations in winter. A limited knowledge of animal ways.

Contribution to the concept that the great amount of activity among animals is largely concerned with the problem of obtaining food.

Suggestions

The simplest way to arouse interest and to begin the activity is to observe tracks as they are made. Start the study as soon as possible after a light snowfall, for there will soon be a bewildering maze of tracks.

Compare your tracks with and without overshoes. Learn to distinguish the tracks of men, women, and children.

Run, and compare your running tracks with those made in walking.

Bring pet dogs, cats, and rabbits to school, and observe the tracks that they make in the snow. Watch the birds, and observe their tracks. Draw pictures of the tracks that you observe.

After some familiarity with the tracks of common animals is gained by watching as they are made, you are ready to begin to trace their paths and interpret their activities. If the snow is badly trampled by this time, wait until the next snowfall to continue the study.

Human Tracks.—Follow the tracks across the school ground and near-by lots to discover where they lead. See if you can guess where the people have come from and why they are going in these directions.

Horse Tracks.—By looking for the imprints of the sharp calks on the shoes which keep their feet from slipping on the frozen ground, discover whether or not the horses wore shoes. Discover what vehicle they were pulling, and discuss what they were probably hauling.

Squirrel Tracks.—Track the squirrels to their den trees in the park or woods. Note where they have dug in the snow to uncover nuts and other buried food.

Rabbit Tracks.—Track rabbits to their dens. Find the places along their trails where they have sat and packed the snow.

Bird Tracks.—Find where the tracks are very abundant, and try to discover what the birds found to eat there. Scatter some food on the snow; study the tracks of birds and other animals that come to get it. Visit a chicken yard and note how completely it is covered with tracks.

Other Tracks.—Look for other tracks. Go as far as the interest and ability of the children permit in comparing the feet of the different animals, their suitability for traveling in snow, and the manner in which the animals travel.

Casts of animal tracks in sand can be made by pouring plaster of Paris in the tracks and allowing it to harden, but the method does not work well with tracks in snow. It may be interesting to try it in the classroom.

Contributing Learnings

Most animals, including man, are less active during winter. As their tracks are not so easily seen at other seasons, we do not realize how much the earth is trod. Footprints in snow tell a story of the activities of animals, as do our tracks on the floor when our shoes are muddy, while we pay little attention to the footprint evidences of animal activities at other times.

Human beings and domestic animals carry on many of the same activities in winter as in summer. Wild animals travel about mainly in search of food.

The appearance of the footprints in snow depends upon the shape of the feet and the way in which they are used. Four-legged animals do not always move the feet in the same order. Some animals drag the feet or the body and make long prints in the snow. We can usually tell what animals have made the tracks. (See the references for drawings and photographs of the tracks of animals.)

Human beings wear covering on the feet to protect them from injury, from cold, and from dampness. The toes of horses, cattle, hogs, and some other animals have a horny covering. Birds have hard scaly skin coverings on the feet and lower legs.

Dogs, cats, rabbits, squirrels, and many other animals have pads of tough thick skin on the bottoms of their feet.

References

*ATHEY, LILLIAN COX: "Along Nature's Trails," New York: American Book Company, 1936, pp. 7–47.

*"Handbook for Boys," New York: Boy Scouts of America, 1931.

*CARR, WILLIAM H.: "The Stir of Nature," New York: Oxford University Press, 1930, pp. 37–47.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 213–260.

**Cornell Rural School Leaflet*, Vol. 25, No. 3: In the Woods in Winter, Ithaca, New York: Cornell University, June, 1932.

CRAM, WILLIAM EVERETT: "Little Beasts of Field and Wood," Boston: Small, Maynard & Company, 1899, pp. 3–21.

MANN, PAUL B., and GEORGE T. HASTINGS: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 24–34.

NELSON, E. W.: "Wild Animals of North America," Washington, D. C.: The National Geographic Society, 1930, 249 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 91–98.

*——— and ———: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 91–98.

*ROSSELL, LEONARD: "Tracks and Trails," New York: The Macmillan Company, 1928, 137 pp.

SETON, ERNEST THOMPSON: "Life Histories of Northern Animals," New York: Charles Scribner's Sons, 1909, 1200 pp.

BEFRIENDING THE WINTER BIRDS

Aims

Enjoyment of wild birds in winter.

Conservation attitudes through participation in conservation activities.

An elementary concept of the controlling role of climate and of food as the great problem of existence for most animals.

Suggestions

It is well to make plans before the heavy snows and sleets come. Become acquainted with the commonest winter birds about the school and with their food habits. In the north, where birds are most likely to suffer, the number of kinds is rather small. It may include the game birds.

Select a place to be kept free of snow during the winter for a feeding place on the ground. Also, attach a feeding shelf to a tree trunk. The feeding place should be in a sheltered location, if possible. Consult the references for suggestions and devices for winter feeding stations.

In order that the birds may know where to come for food later, begin the feeding before severe weather arrives. Wedge suet in the crevices of the bark of trees for woodpeckers, nuthatches, and chickadees.

Scatter bread crumbs, seeds, etc., on the ground for such birds as juncos, sparrows, jays, and pigeons. Keep the shelf well filled with a variety of foods.

The ideal, of course, is a bird haven, with its windbreaks, edible winter fruits, feeding places, etc. Plan such a place as a future development.

Observe the birds that appear as winter boarders. Record what each bird eats. Describe their ways and your experiences with them. Mount their pictures in the schoolroom. Enjoy them in story, poetry, and song. Make booklets of your experiences with the winter birds.

Contributing Learnings

Most birds leave the north before winter comes. We do not know why they go southward, but the increasing shortage of food here may be one reason.

Only a few kinds of birds are seen commonly in winter around our homes and schools in the north. These include English sparrows, juncos (except during mid-winter), jays, some crows, nuthatches, cardinals, hairy and downy woodpeckers, chickadees, and pigeons. The chicken-like game birds, pheasants, bobwhites, prairie chickens, and partridges are commonly seen in many rural districts. The pheasants frequently come to eat with the farmers' chickens. There are other winter birds, but only a few kinds are commonly seen.

The few winter birds seem to find plenty of food and do not need our help until the heavy snows and sleets of winter come. During these periods, when their natural foods are deeply buried or covered with sleet, large numbers of birds starve.

These birds are our fellow creatures, and we wish them to have plenty of food. Moreover, if we feed them during times when they cannot otherwise get food, they will destroy many weed seeds and harmful insects during the remainder of the year.

Nuthatches, chickadees, and woodpeckers search the trees for insects. When they cannot get insects, they like suet best of all our foods.

Sparrows, juncos (really sparrows), jays, and pigeons seem to prefer weed seeds and fruits but also eat many insects. At our feeding places they usually eat mostly seeds and foods made of seeds (bread, etc.), but some of them also feed on juicy fruits, leafy vegetables, and suet.

Birds soon lose their fear of us if we befriend them.

References

ALLEN, ARTHUR A.: "The Book of Bird Life," New York: D. Van Nostrand Company, Inc., 1930, 416 pp.

*ATHEY, LILLIAN COX: "Along Nature's Trails," New York: American Book Company, 1936, pp. 159–202.

BAYNES, ERNEST HAROLD: "Wild Bird Guests," New York: E. P. Dutton & Company, Inc., 1915, 326 pp.

BOND, FRANK: "My Bird Boarders," Washington, D. C.: The Green Lamp League, 1933, 104 pp.

CHAPMAN, FRANK M.: "Our Winter Birds—How to Know and How to Attract Them," New York: D. Appleton-Century Company, Inc., 1919, 178 pp.

**Cornell Rural School Leaflet*, Vol. 29, No. 3: Conservation, Ithaca, New York: Cornell University, January, 1936.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 69–80.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush & Company, 1930, pp. 68–69.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book V, New York: Silver, Burdett & Company, 1935, pp. 45–53.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 69–79.

*PATTESON, S. LOUISE: "How to Have Bird Neighbors," Boston: D. C. Heath & Company, 1917, 131 pp.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 41–44.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 117–123.

*——— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, p. 95–104.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 110–118.

TRAFTON, GILBERT H.: "Bird Friends," Boston: Houghton Mifflin Company, 1916, pp. 249–259.

*———: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 125–133.

COMPARING THE CHRISTMAS TREES

Aims

Enjoyment of evergreens and a desire to see them increased rather than destroyed. Satisfaction through being able to recognize types of evergreens.

Suggestions

Early in December, before the Christmas trees are shipped in, is a good time to begin. Visit pines, spruces, firs, and junipers. In the lower grades it is not necessary to distinguish the species of each. Hemlock, larch or tamarack, arborvitae, and yew may be omitted if the distinctions prove confusing.

Decide which have the most beautiful shapes. Note whether or not the needles cover the entire branches, presenting an almost solid mass of green. Brush the foliage with the hand to discover whether the leaves are too sharp-pointed, stiff, and scratchy to decorate and work around them easily. Compare the odors.

Try to secure a small branch of each evergreen. Stand the branches in the sand table, and watch to see which kind keeps its leaves longest.

Work out the differences among the types of evergreens. When the Christmas trees are shipped in, discover what kinds they are. Just before Christmas, visit growing evergreens which have been decorated as Christmas trees. Consider the advantage of this method over that of cutting the trees. Talk over the other uses of evergreens and why we like them so much. Look over some of the beautiful catalogues showing the uses of evergreens as ornamentals. Plan to plant some seeds of evergreens in the spring.

Contributing Learnings

Evergreens have small leaves. They are usually needles, awls, or scales.

The needles of pines are in bundles with a sheath about the base. The leaves of the other evergreens are separate.

Spruces have four-sided needles. We can easily feel the corners or edges of a spruce needle by rolling one between the thumb and forefinger. Fir needles are flat, and they merely slide when

we try to roll them in this manner. The needles grow on all sides of a spruce twig, giving it a similar green appearance from all directions. Fir needles grow mostly on two sides of the twig, looking as if they had been parted like hair by a comb.

Junipers have scales and awls instead of needles. The red cedar is the commonest juniper. It has fine scales so closely pressed about the slender, cylindrical twigs that we hardly notice them. Sometimes red cedars have awl-like leaves. The scale leaves of arborvitae lie flat to the twigs on two sides, giving the sprays of twigs a fanlike appearance.

Firs retain their needles longer than spruces when cut for Christmas trees. The balsam fir is more odorous than the spruces, but the foliage is not so heavy. Blue spruces are beautiful trees, but they have stiff, sharp leaves which scratch us when we brush against them. Pines are coarser and are more beautiful from a distance than at close range. In the south, broad-leaved evergreens are often used for Christmas trees.

Most of the evergreens shipped in for Christmas trees are spruces. Some are firs. A few people plant evergreens for Christmas trees, but most of them are cut from the woods. They are largely black spruce and white spruce from the north woods. Many of the trees in the north are evergreens. It would be much better to grow them as a crop than to destroy natural forests in this way. Norway spruce is often grown for Christmas trees. A much better plan is to plant an evergreen close to the house and decorate it each year.

Evergreens furnish most of our lumber and many other useful products. We prize them also because they retain the beauty of their green leaves even in winter. Many evergreens can be grown easily from seeds.

References

BLAKESLEE, ALBERT F., and CHESTER D. JARVIS: "Trees in Winter," New York: The Macmillan Company, 1913, 429 pp.

EMERSON, ARTHUR I., and CLARENCE M. WEED: "Our Trees—How to Know Them," Philadelphia: J. B. Lippincott Company, 1908, 295 pp.

Nursery catalogues.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 80–90, 128–130.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 49–52.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 107–111.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 76–81.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 119–132.

*——— and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 128–136.

ROGERS, JULIA ELLEN: "Trees That Every Child Should Know," New York: Grosset & Dunlap, 1909, pp. 101–131.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book I, Philadelphia: J. B. Lippincott Company, 1931, pp. 130–134.

HOLDING A WINTER FLOWER SHOW

Aims

Interest in growing plants for personal satisfaction.

Ability to make a contribution to the home.

Background experience for understanding and desirable attitudes concerning sex and reproduction.

Suggestions

A winter flower show just before the Christmas vacation is the natural culmination of the fall activity "Starting the Bulbs for a Winter Flower Garden" (see the account of this activity).

If the bulbs have been started early in a dark place and brought into the schoolroom in November with well-established root systems, they will come into bloom during December.

It is well to depend mainly on narcissus the first time that this activity is carried out, although tulips, hyacinths, and some of the other types described in the fall outline should be included.

The flower show can be held at the time of a parent-teacher meeting or other school program to which the public is invited. If the flowers are to be sold to pay the expenses connected with the activity, they should be just opening into bloom. Plants that have been in full bloom for some time obviously are not readily salable. If they tend to bloom too early, hold them back by keeping them in a cool place. If the activity is financed otherwise than through sale of the plants, the children will get a great deal of satisfaction through growing the flowers for their homes.

Find the ovaries of the flowers, with the tiny seeds developing within them. Observe the pollen which is necessary to make them develop. Pollinate a flower, and watch to see whether seeds develop. Discover whether other flowers get pollinated without our aid. Examine and compare the different kinds of flowers.

When the flowers are no longer attractive on any of the plants remaining unsold, the developing fruits should be removed, and the bulbs allowed to grow as large as possible for use another season. If some one will plant the bulbs out-of-doors in the

spring and care for them during the summer, there will be a supply of strong bulbs for next year's show.

Contributing Learnings

When plants are nearly full-grown, they usually flower. Each kind of plant has a different flower. But while the flower faces are different, the flowers are much alike. The petals and sepals may be different in color and shape, and the flowers may be large or small, but they all have parts for producing baby plants.

When we pinch open the ovary in the center of the flower, we find tiny ovules like grains of sugar which develop into the seeds containing the baby plants. The ovary grows into the fruit. Outside the ovary are slender threadlike stalks bearing pollen. The baby plants will not develop in the ovules, and the seeds will not ripen, without this pollen. To us flowers mean beauty. To the plants they are the means of producing offspring.

Many plants have other ways of producing their kind as well as by seeds. Those which store food in bulbs or roots to start next year's growth are our earliest flowers to bloom out-of-doors in spring. As they already have enough food stored to produce flowers, they are most suitable for growing indoors in winter. Some plants, such as Colchicum, store enough water as well as food to produce blossoms.

It is possible for all of us to have flowers in our homes. Any boy or girl can have an interesting time growing flowers from bulbs and can thus bring much happiness to other people. By planting the bulbs out-of-doors in spring, we can grow flowers year after year without expense. During the summer the plants make food and store it. They are then ready for another blooming season.

(See the description of the fall activity "Starting the Bulbs for a Winter Flower Garden," for other contributing learnings.)

References

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 596–606.

**Cornell Rural School Leaflet*, Vol. 20, No. 3: House Plants, Ithaca, New York: Cornell University, January, 1927.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 73–77, 86–89.

"Dreer's Hints on the Growing of Bulbs," Philadelphia: Henry A. Dreer, 79 pp.

*FISHER, CLYDE, and MARION L. LANGHAM: "Nature Science," Book I: "World of Nature," New York: Laurel Book Company, 1934, pp. 92–94.

*——— and ———: "Nature Science," Book IV: "In Field and Garden," New York: Laurel Book Company, 1934, pp. 70–75.

MEIR, W. H. D.: "School and Home Gardens," Boston: Ginn and Company, 1913, pp. 5–19.

*NICOL, LUCILLE, SAMUEL M. LEVENSON, and TERESSA KAHN: "The Nature Hour," Book V, New York: Silver Burdett & Company, 1935, pp. 34–38.

*PERSING, ELLIS C., and ELIZABETH, K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 89–93.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 11–17.

GROWING A WINTER GARDEN OF TWIGS

Aims

The satisfaction that growing things bring. Anticipation of spring and interest in watching for spring developments.

Some understanding of the conditions necessary for growth.

Experience contributing to understanding and desirable attitudes concerning reproduction.

Suggestions

It is well to wait until later in the winter to begin this activity, as a better growth is obtained after the trees and shrubs have gone through a period of winter dormancy. Any time after the Christmas holidays is satisfactory. The later in winter the twigs are cut the shorter will be the period required to bring them to flower and leaf in the schoolroom.

The early-blooming woody plants are most quickly and easily forced indoors in winter. Try willows, poplars, elms, plums, crab apples, maples, box elder, buckeye, Juneberries, golden bell (Forsythia), golden-flowering current, hazel, and dogwoods. Add a few others of the woody plants growing in the vicinity of the school for trial.

Cut twigs eighteen to twenty-four inches in length which show some strong swollen buds. Teach the children to make clean cuts and to avoid breaking, peeling, and otherwise mutilating plants. It is well to cut willow, poplar, and box-elder twigs from more than one tree, as some trees of these species produce staminate and others pistillate flowers. The pistillate box elders can easily be recognized by the few old winged fruits still hanging on them.

Stand the twigs in vessels of water in the schoolroom, and change the water every few days. Cut off a little of the base of the twig each time to expose open conducting tissue.

Observe the twigs before growth appears. Note that the buds are formed ready to grow into flower shoots and leafy twigs. Open a large bud on a cottonwood twig. Guess whether flowers or leaves will first appear. Count the buds on a twig, and watch to see how many grow.

Make daily observations, and report the swelling of buds, the growth of twigs, the first appearance and rate of growth of leaves, the development and nature of the flowers, the shedding of pollen, and the appearance of any fruits. Test the pollen by blowing it and by thrusting a pencil in the flower, to discover whether it would be likely to be carried by wind or by insects.

When growth has practically ceased, the twigs may be preserved by pressing them, and comparison made several weeks later with the outdoor growth of the same plants.

Contributing Learnings

Trees and shrubs (except evergreens) live through the winter without their leaves and, therefore, cannot make food. Evergreens manage to make a little food in winter. Plants can obtain very little water from the cold and often frozen ground.

Most of the trees and shrubs manage to live through the unfavorable winter until suitable conditions for growth return. They have stored some food in the twigs (mostly in roots) during the spring and summer and formed many buds, or growing points. In some of these buds the tiny flowers can already be seen.

When we bring the twigs into the warm room and give them plenty of water, they use their stored food and develop as if spring had come. We place the twigs in the sunlight where the new leaves will become green and make more food.

On some kinds of twigs the flowers develop before the leaves. These are mostly the trees that flower very early in the spring. Most of them do not have large showy flowers which would attract insects. Their pollen-bearing flowers usually hang in catkins. Very few insects would be flying about so early in the spring. The pollen is easily blown about by our breath and would be scattered widely by the strong spring winds.

The pollen must be carried to the pistils of the flowers. Otherwise, they will not form fruits. Some flowers have both stamens (recognized by the anthers bearing the pollen) and pistils (look for the swollen ovaries where the seeds will form). The stamens and pistils of willows, poplars, and box elders are on separate trees. As the stamens produce only pollen which causes the pistils to develop, the stamen-bearing willow, poplar, and box-elder trees never bear any fruits.

Fruits contain seeds. Each seed is a baby plant together with some stored food and protecting coats. A seed is capable of producing another tree much like the parent. Fruits are of many shapes, types, and sizes. The first tree fruits to form are on the elms. They resemble the gun caps shot in toy pistols on the Fourth of July. Where the powder in the gun cap would be, there is a seed.

By bringing the twigs into our summer-like schoolroom, we can enjoy their blossoms earlier and can gain some idea of what will take place when spring comes. The cut twigs do not make such good growth as those that are left on the trees, as they have only their own stored food with which to grow and make new leaves. When the sap rises, the twigs on the trees receive sugar from the supply stored in the roots.

References

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 731–789.

EMERSON, ARTHUR I., and CLARENCE M. WEED: "Our Trees—How to Know Them," Philadelphia: J. B. Lippincott Company, 1908, 295 pp.

*GORDON, EVA L., and JENNIE HALL: "Nature Stories for Children—A Spring Book," New York: Mentzer, Bush & Company, 1927, 90 pp.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush & Company, 1930, pp. 88–90.

OTIS, CHARLES HERBERT: "Michigan Trees," Ann Arbor: University of Michigan, 1915, 247 pp.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 85–87.

COMPARING OUR DOGS

Aims

Interest in dogs and appreciation of the splendid qualities of the better breeds and mixed breeds.

Some ability to choose good dogs for companions.

Simple experience contributing to the concept that we can partially control and improve the stream of life.

Suggestions

Use any available dog of even disposition and rather evident breed to begin the study. Let the children pet him and learn something of his disposition and ways. Notice how he differs from other breeds of dogs. Read stories of dogs of this breed.

As soon as interest is aroused, children will begin to tell of their own dogs, how they differ from this dog, and what they can do. There will be many mixed breeds and some fairly distinguishable types, such as collies, hounds, spitz, spaniels, police dogs, bulldogs, terriers, poodles, and miniature or toy dogs of various breeds. Dogs have interbred to such an extent that the determination of the breed is almost impossible in some cases, but this need not prevent the study of a few common types.

Wholly safe dogs may be brought to school, and field trips may be taken to visit some of the homes where dogs are kept. Dog owners will be glad to cooperate. If there is a Saint Bernard, a Newfoundland, a great Dane, or other noted but less common type of dog in the community, try to visit it.

Compare the dogs in many ways. Note which are swiftest runners and what uses they have had. Discover which breed of dogs can do the most tricks. Which are water dogs? Which dig most in the ground after animals? Which make up readily with strangers, and which are "one-man" dogs? Which are good watchdogs and will stay with any garment or object to guard it? Which like to drive farm animals? Which are gentle, and which fierce? Which are most playful? Which track best? Which retrieve objects? Which stay at home, and which roam about most? Compare the shapes, sizes, coats, legs, ears, and mouths of the different breeds.

Read many stories of dogs, selecting those which are likely to be true. Discuss the uses of dogs and why they are our best companions among the animals. List the things that dogs can do better than we can do. Collect dog pictures.

Contributing Learnings

The dog was man's first domestic animal. We do not know from what animals dogs came, but many of them resemble wolves and coyotes.

Dogs are more intelligent than most of the other animals and learn to do many things. They have been very useful in hunting game for our food; guarding our property; pulling loads; carrying messages; bringing aid; rescuing lost and drowning persons; protecting children; herding sheep and other animals; destroying rats, gophers, and other pests; and serving as companions.

By keeping only the best dogs, some wonderful lines of dogs were developed in the past. Dogs have interbred until many mixed breeds occur. Some people call mixed breeds "curs," but many splendid dogs have been developed when good types interbred. Today many useless freak dogs have been developed along with some splendid ones. Most of the dogs developed for toy size and unusual appearance lack the intelligence, usefulness, and good disposition of the fine old breeds of dogs. Dogs that would not win prizes at a dog show saved many lives during the World War.

Dogs of the same breed differ somewhat but usually have much the same appearance and nature. The common breeds of dogs usually show some of the characteristics listed in the following paragraphs.

Spitz.—Small; white or cream colored, sometimes darker or even black; long haired; narrow faced; alert and pretty; choosy and of uncertain temper, likely to snarl or snap at strangers.

Collie.—Medium-sized dogs of various colors; long, straight, and often rough haired (a few are smooth) with woolly undercoat, the hair on the throat and chest being especially long, sometimes much fluffed and curled in animals reared for show; head broad in the common collie and shepherd; attractive; intelligent and courageous; famous sheep and cattle dogs; of good disposition; excellent companions.

German Shepherd or Police Dog.—Medium to large dogs resembling wolves; the color of a wolf, the longer hairs dark tipped, the

muzzle usually blackish; clean-limbed, powerful, and alert; very intelligent and learn readily; good sheep dogs and one of the most famous dogs in the World War; restless but rather dignified; dangerous if they are neglected and revert to the wild state, must always be watched in town.

Spaniels.—Ears long and silky; frank expression; very affectionate and kind, sometimes a little shy with strangers, charming, dignified, but very playful; splendid companions, excellent hunting dogs and water dogs used to retrieve and flush game; of several breeds. Irish water spaniels—dark or reddish brown, with tightly curled hair except on the ratlike tail. Springer spaniels and cocker spaniels—often black or black and white.

Terriers.—Usually small, except airdales; bright; do not tire easily; persistent diggers in the ground after rats, gophers, and other animals; courageous and inclined to be ready to fight at all times; of several breeds differing considerably in appearance. Irish terriers and airdales—sandy colored and rather wire-haired with beardlike hair on the chin and lip. Airdales were famous for Red Cross service in the war. Fox terriers—smooth haired or rough haired. Boston terriers—a cross between a bulldog and a terrier; usually black with white muzzle; clean, bright, playful dog kept as a companion; shows the bulldog nature and will cling tenaciously to a ball or stick.

Bulldogs.—Low, broad chested, bowlegged, powerfully muscled; with wrinkled faces, exposed teeth, and very short noses, naturally a good dog but many are short-winded, short-lived, and hardly able to eat with their deformed mouths; known for courage and sticking qualities; used as a watchdog because his appearance frightens people, actually a gentle companion.

Poodle.—Small (some are larger); hair curly or long and straight; often appearing to have a beard and mustache; self-colored, black, brown, reddish, tawny, or white; eyes small; extremely intelligent, learns tricks easily and is usually the performer in shows.

Saint Bernard.—Huge dogs with large heads; solemn expression; very deep voices; quiet, dignified manner and wonderful disposition; famous for ability to rescue travelers in the snowy Alps; much prized here.

Toy Dogs.—Of several breeds—Pomeranian, Pekingese, toy spaniels, toy poodles, etc. Children will probably call all of them toy dogs. (See the references for distinctions.)

Hounds.—Of many breeds. (See pictures and descriptions of the various types.)

References

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 261–267.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 250–257.

*DUPUY, WILLIAM ATHERTON: "Our Animal Friends and Foes," Philadelphia: John C. Winston Company, 1925, pp. 261–267.

*"Book of Dogs," Washington, D. C.: National Geographic Society, 1927, 109 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 122–128.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades, Book III," New York: D. Appleton-Century Company, Inc., 1928, pp. 106–113.

SMITH, A. CROXTON: "Tail Waggers," New York: Charles Scribner's Sons, 1931, 146 pp.

U. S. Department of Agriculture, *Farmers' Bulletin* 1491, Breeds of Dogs.

*WHITE, MARGARET L., and ALICE HANTHORN: "Do and Learn Readers," Book III: "Interesting Things to Know," New York: American Book Company, 1930, pp. 7–36, 112–120.

LISTING OUR FRIENDS AND FOES

Aims

A more intelligent attitude toward other forms of life and a greater appreciation of them.

Greater ability to utilize helpful agencies and to prevent injury from the harmful ones.

A wider range of interests in the varied forms of life.

A better concept of man as part of nature, not a ward of it.

Some conception of the fundamental roles of green plants and fungi in making continued existence on the earth possible through bringing about recurring cycles of synthesis and decomposition.

Suggestions

When questions arise concerning killing snakes, toads, crows, sparrows, insects, weeds, worms, and bacteria, it is not difficult to interest children in looking up the records of the various forms of life as a basis for more intelligent action.

Let the children prepare first a list of the groups of living things found in the region. The list will no doubt contain some of the trees, shrubs, herbaceous seed plants, ferns and their relatives (club mosses and horsetails), mosses and liverworts, algae, fungi (molds, mushrooms, rusts, smuts, mildews, yeasts, bacteria, etc.), lichens, mammals, birds, reptiles, amphibians, fishes, insects, crustaceans, spiders, mites and ticks, millipedes and centipedes, mollusks (mussels, snails, slugs), worms, sponges, and one-celled animals. If near the ocean, add starfishes and other spiny-skinned, wheel-like animals, jellyfishes and corals, and their relatives, etc.

The task is so large that it is well to let the pupils divide it among themselves. Let each child find out as much as possible about the relation of one or more of these groups of plants and animals to our welfare and report to the class. He should also bring an example of the group, if possible, to acquaint the class with unfamiliar types.

The pupils should discuss the reports and attempt to compile a general list of friends and foes. While the list will be far from complete and will introduce many problems that cannot be fully

solved, it will serve to develop certain desired attitudes and concepts.

Contributing Learnings

There are relatively few forms of life that do us any great amount of injury.

A few species of bacteria and other fungi attack us, our domestic plants and animals, our foods, and other things that we value.

A considerable number of insects attack our possessions. Some insects, mites, and ticks are important in the spread of diseases. They are carriers of disease organisms rather than direct causes.

A few seed plants poison us. Many more are troublesome weeds which compete with our crop plants.

A very few species of snakes poison us, but the death rate from snake bites in this country (an average of two per year) is less than from almost any other cause.

Some species of worms are parasites of man, other animals, and certain of our crop plants.

A few other forms of life do a certain amount of damage to our interests.

On the other hand, many of the other groups of animals and plants are necessary for our existence.

Seed plants furnish most of our food, part of our clothing, most of our shelter, part of our fuel, our paper, many of our implements, and other useful articles. They give us shade, beauty, and recreation.

From the ferns and their relatives which covered the earth before seed plants became numerous have largely come our supplies of coal, oil, and gas, which not only serve as fuel for heat and power but out of which the chemists make hundreds of our useful products.

Mosses and grasses form peat, help to form soil, and add beauty to our surroundings.

The algae are the most important basic food for smaller forms of water life which, in turn, furnish food for fishes. They also form islands.

Fungi decay each generation of plants and animals, returning them to the soil and making possible new generations of life on the earth. They also help us in making butter, cheese, bread, vinegar, pickles, sauerkraut, ensilage, leather, linen, and other

products. Some bacteria also put nitrogen in the soil and aid the growth of plants.

The lichens are the pioneer soil formers on rock, growing on bare rock where nothing else can live and gradually helping to build a soil. As all of the surface of the earth was once rock, they have probably been of tremendous value.

Animals are supported by plants, but they furnish us directly with many of our needs of life. They provide much of our food and clothing and serve as domestic animals and companions.

Birds help us to control the destructive insects and furnish meat and eggs.

Reptiles help to control rodents and insects and are used for food, shoes, and other articles.

Frogs, toads, and salamanders destroy countless insects.

Fishes are important as food and as destroyers of mosquitoes and other insects.

Crustaceans furnish food. Spiders and centipedes kill many insects. The insects as a whole are even greater friends than foes, as they pollinate our plants. Many serve as food for other useful animals. They also furnish silk, honey, shellac, and other products. Many species destroy other insects.

Earthworms often improve our soils.

The one-celled animals have formed islands and chalk cliffs. They improve water filters and serve as food for other water animals.

A very large portion of the living world is directly neither markedly harmful nor beneficial to us. Even from a selfish standpoint these neutral forms of life ought not be destroyed, as they make life more interesting.

The few forms of life that endanger our existence we must avoid or control where we can. Our fears and destruction of many of them are unwarranted, being based on very exaggerated ideas of the danger from them, as when people kill snakes, toads, or any species of insect that they happen to see, and fear all bacteria as disease germs.

References

*Beauchamp, Wilbur L., Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 100–103.

*CRAIG, GERALD S., and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 233–253.

*——— and MARGARET G. CONDRY: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 343–375.

*DUPUY, WILLIAM ATHERTON: "Our Animal Friends and Foes," Philadelphia: John C. Winston Company, 1925, 274 pp.

*———: "Our Insect Friends and Foes," Philadelphia: John C. Winston Company, 1925, 275 pp.

*———: "Our Bird Friends and Foes," Philadelphia: John C. Winston Company, 1925, 319 pp.

*GEHRS, JOHN H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 1–73, 94–100, 137–142.

*———: "Nature Study," Book II, New York: American Book Company, 1930, pp. 43–76, 102–173.

*PERSING, ELLIS C., and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 13–45, 55–61, 80–158, 252–259, 280–288.

*——— and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 17–38, 53–96, 106–113, 226–249, 291–309, 318–323.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company 1931, 210 pp.

COMPARING OUR RANGE OF FOODS

Aims

Increase in the children's range of foods to insure getting all body needs and to make the problem of planning meals for the family easier.

Background experience for the conception of health as a matter of physiological balance.

A degree of prophylaxis against food fads and unscrupulous advertising.

Suggestions

If the question is raised as to who eats the greatest range of food materials, there will be immediate active interest. Let each child list the various plant and animal parts that he eats.

To help in the classifications of plant parts, let the children bring to school samples of all kinds of plants used as food. Arrange them in groups according to the parts that serve as food —leaves, flowers, fruits, seeds, stems, buds, roots, and sap.

Classify the animal foods similarly. Make a trip to the meat market to see all forms in which the various kinds of animal products are sold.

Make individual charts showing the foods of each type (plant or animal part) eaten. Use pictures from old seed and nursery catalogues and magazines.

Encourage pupils to increase their range of foods, especially those children who have learned to eat only a very few things. Let each child add to his chart the new foods eaten.

Read about the foods eaten by other peoples.

Talk about what the different foods supply to the body until children realize the importance of eating a range of foods. Avoid overemphasizing any one food as the faddists and unscrupulous advertisers do. Expose some of the exaggerations in food advertising.

Contributing Learnings

We eat the leaves of spinach, lettuce, endive, Swiss chard, beets, mustard, dock, lamb's quarter, and dandelion. Of rhubarb and

celery we commonly eat only the petiole of the leaf and throw away the blade. Leafy foods are body regulators. They do not furnish a great amount of energy.

We eat the stems of asparagus and kohlrabi. Irish potatoes are fleshy underground stems. They are much like roots in food value.

We eat the roots of many plants, among which are sweet potatoes, beets, carrots, salsify, radishes, turnips, and rutabagas. Roots, being storage regions, contain some starch and other foods. They are less concentrated than seeds. They are less valuable sources of vitamins than the rapidly growing tips and leaves of plants.

We commonly eat the fleshy buds of cabbage and onion. We eat many kinds of fruits of plants. Some of the fruits such as green beans and corn are usually classed as vegetables. Fruits are watery and low in energy value. They are important, however, as body regulators.

Seeds of plants make up a large part of our foods. Each seed is a concentrated package of starches, proteins, and fats sufficient to start a new plant.

We eat the fleshy flower of cauliflower.

The sap of maple trees, cane, sorghum, and sugar beets furnish us sweets which may be eaten in limited quantity.

Lean meats furnish us protein for growth and repair, some energy, and minerals. Meats are lacking in calcium (lime is a sufficiently accurate word). Fats furnish a large amount of energy but little else.

Milk contains much lime needed in bone and teeth building and as a general body regulator. It is the only food that supplies all of the kinds of vitamins needed in the body. In winter, milk may lack certain vitamins. Milk is not a complete food, as we sometimes hear stated. It is low in iron. Iron is needed to form red blood in us, as it is needed to build leaf green in plants.

Honey is energy food.

The yolk of eggs contains energy-giving fats and some minerals and vitamins to act as body regulators. The white of the egg is mostly protein.

The organs of animals are sources of protein and energy, but they are more valuable as body regulators. Liver and liver extract are fed to people who are anemic, and some other organs furnish body regulators.

There are many food fads and many extravagant and unwarranted claims by advertisers regarding the values of certain foods. It is not necessary to work out the food values in every meal that we eat, nor is it necessary to buy certain highly advertised foods.

The best way to get all body needs is to eat a wide range of foods. Unless certain foods disagree with us, it is wise to learn to eat them all. Experience has shown that some of those which we do not like at first often later become favorite foods.

It is part of our education to learn to eat a wide range of foods for citizenship as well as for health. We are better guests and better members of scouting and other social groups when we learn to enjoy the foods served.

It is better to buy our foods in their natural form and to prepare them than it is to buy them in highly processed form.

References

*BEAUCHAMP, WILBUR L., HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 92–97.

LOWENBERG, MIRIAM E.: "Food for the Young Child," Ames, Iowa: Collegiate Press, 1934, 142 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III: "Surprises," New York: The Macmillan Company, 1933, pp. 61–93.

*——— and ———: "Nature and Science Readers," Book V: "Science at Home," New York: The Macmillan Company, 1934, pp. 365–423.

ROSE, MARY SCHWARTZ: "Teaching Nutrition to Boys and Girls," New York: The Macmillan Company, 1932, 195 pp.

COMPARING OURSELVES WITH OTHER ANIMALS

Aims

Contribution to the concept that through development of a more complex nervous system man is able to compete with other forms of life which excel him in many respects and to achieve a limited control over existence.

Some realization of the limitation of our present knowledge of living things.

A degree of respect and consideration for other forms of life.

Suggestions

Begin with any animals at hand by discovering what they can do. How do they move about? Can they walk, glide, swim, run, jump? How fast can they go? How well do they seem to hear, see, and smell? What means have they of escaping or avoiding their enemies? Do they build homes? Do they live a social life and help each other? Do they seem to have a language? Can they learn from the experiences of previous generations? How well do they seem to think?

Interest the children in bringing other animals to school for similar study. Visit places where animals are kept.

Try to include some of the mammals—monkeys, dogs, cats, horses, cattle, rabbits, mice, rats, etc.

Include other chordates—birds, snakes, lizards, turtles, toads, frogs, salamanders, and fishes.

It is well to study a number of kinds of insects such as grasshoppers, flying insects of some kind, water insects, and a social type such as ants.

Bring in earthworms for study.

There is a strong tendency for children to imagine rather than be guided by evidence. Make the activity an experience in scientific thinking by letting each pupil furnish evidence for his statements. Recognize fully the limitations of such hasty observational evidence.

Contributing Learnings

We are not superior in every way to all other forms of life. In nearly all respects there are forms of life that far excel us.

Some other animals have keener vision. The birds flying above the earth can see small objects on the ground clearly which would be hardly visible to us at that distance. Their eyes are somewhat like a telescope.

Many of the wild animals have much more acute hearing than we have. Our dogs hear visitors coming and notify us.

Our sense of smell is very dull compared to that of a great many animals. If a female moth is placed in a cage on the window sill at night, other moths from a considerable distance about will find her. We marvel at the ability of the dog to scent and track game. Many of the wild animals apparently recognize faint odors.

We are poor travelers without the aid of our machines. Great numbers of the other animals can run faster and longer distances. They swim naturally. Some can remain beneath the surface, using the air in the water. Bats, many birds, and insects are remarkable fliers. We are not the best athletes. If we could jump as far in proportion to size as fleas do, our leap would be several hundred feet.

Many animals can withstand heat and cold better, have more protective coverings, and can hide or otherwise escape their enemies better than we. Some can live on foods that we cannot eat. Others require little food and could exist in case of a food shortage over the earth that would produce a famine for man.

Each form of higher life seems to have developed certain powers and advantages. We excel in development of the central nervous system, which makes it possible for us to remember longer, to have a written as well as a spoken language, to learn from the past, and to plan ahead. To have developed in this way has given us more power than if we excelled in some other respect. It makes it possible for us to foster, to control, or to destroy many other forms of life which are our superiors in other respects. It ought, also, to enable us to understand and appreciate the other animals for their wonderful powers. At present, we do not fully understand them or ourselves. Our acts are not always intelligent. We destroy many of the other animals unnecessarily, suffer the attacks of many others, and have many foolish fears and repugnances.

Our superiority over other animals, being in only one respect, does not give us complete control over them. We are forced to compete with certain of them for our very existence and cannot afford to underrate their powers.

References

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1933, pp. 5–18, 143–162.

*——— and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 191–262.

*——— and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 122–161.

*——— and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 205–256.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 31–38, 125–132, 145–178.

*GEHRS, JOHN H.: "Nature Study," Book I, pp. 101–136; Book II, pp. 1–10, New York: American Book Company, 1929, 1930.

*PERSING, ELLIS C., and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 8–37, 47–61, 89–124.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 32–45, 133–141.

*——— and JOHN A. HOLLINGER: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 17–20, 106–113.

*PHILLIPS, MARY GEISLER and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book IV: "Our Earth and Its Life," Boston: D. C. Heath & Company, 1936, pp. 149–255.

SHOWING HOW OUR TOYS WORK

Aims

A wider range of interest in toys and greater enjoyment through play.

A tendency to analyze devices and to use creative powers in play.

Experience contributing to a realization that things operate on the basis of natural laws which are dependable and can be understood.

Suggestions

Just after the Christmas vacation is the best time to study toys. Much confusion and responsibility can be avoided by having only a few children bring their toys each day and seeing that these are taken home at the close of school.

It is not possible to study any principle or mechanism in great detail, but the children should work out an explanation that satisfies them. In all cases it should be sufficient to make clear that the toy is based on simple principles rather than magic.

There may be some teachers who believe that to analyze a toy is to rob it of its value in stimulating the imagination and emotions. This hardly seems to be the case, as children have a tendency to take even their favorite toys apart to see how they are made. Analyzing toys should, on the other hand, stimulate creative play activities. Let each child demonstrate and attempt to explain the action of his own toys with the help of the other children.

The mechanisms of most toys can be seen and studied without taking them apart, but it will be necessary to secure an old "mamma" doll and remove the sound mechanism to study it.

List the toys according to the principle on which they operate.

Bring to school homemade toys. Encourage the children to construct simple toys. To get ideas, look over books on making toys.

Contributing Learnings

While only a few of the commoner toys are briefly explained below, it will usually prove a simple matter to discover in a general way how any new toy works.

Dump Trucks.—A windlass elevates one end of the truck to dump the load.

Automobiles That Run.—A spring turns the wheels as it unwinds.

Gliders.—The planes climb on the air when the glider is thrown forward and slightly upward. The air is a real material and when struck suddenly does not give way easily (it is not necessary to call it inertia), as we find when we try to swing a broad bat.

Airplanes That Fly.—These usually contain rubber-band motors. The rubber bands are twisted by winding the propeller. When the propeller is released, the rubber bands untwist, turning the propeller. The propeller blades pushing backward against the air drive the airplane forward, while the planes, which are slightly tilted, climb on the air.

Caterpillar Tractors.—A spring turns the wheels. The rubber chain or belt has lugs which do not slip and enable the tractor to travel well on almost any surface.

Popguns.—A wire extending forward to a cork in the barrel pulls it back as the stock of the gun is bent downward. This compresses the air behind the cork. When the trigger is pulled, the wire no longer holds the cork back. The compressed air forces it forward suddenly, making the pop. In homemade popguns the plunger forces the rear wad forward, thus compressing the air, until the air pressure pushes the front wad out with a pop.

Sleds.—The runners are smooth and soon wear slick, so that there is little friction. Sleds are guided by a crosspiece which, when pulled to one side, bends the runners, thus turning the sled. A Bobsled is really two sleds fastened together so that the front runners can be turned.

Yo-yos.—When thrown from the hand, the unwinding string spins the yo-yo. After all of the string is unwound, the yo-yo continues to spin, thus rewinding the string and bringing the yo-yo back to the hand ready for another cast.

Bows and Arrows.—The bow is bent when the string and arrow are drawn back. When the string is released, the ends of the bow spring forward into place as it straightens, pulling the string forward and sending the arrow forth.

Sandy Andys.—Most Sandy Andy toys work automatically. The loaded car runs down the track and, being heavier, pulls the lighter one up the track on the opposite side. When the empty car gets to the top, it bumps into the container in such a way as to

open it and receive a load. It now becomes heavier than the other car, which by this time has unloaded, and runs back down the track where it strikes a trip and dumps its load. Having become lighter, it is once more pulled to the top by the heavier car which is again loaded and running down the opposite side. The process continues until the container at the top of the tracks is emptied

Tumbling Tommys.—These toys are so nearly balanced on their center rods that they continue to tumble or roll for some time, as does a wheel, once they are started.

Whistles.—When we blow across the end of an empty bottle or vial, the air in it vibrates and makes a sound. The air is blown across the hollow whistle in much the same manner. (While this explanation is inadequate, it is probably more than many children can grasp.)

Harmonicas.—The air blown through the small openings sets the reeds in motion to make the sounds. These reeds make sounds as do the bee's wings. The more rapidly they can move back and forth the higher the pitch of the sound. Some reeds are stiff and vibrate slowly, making low-pitched sounds. Toward the other end of the harmonica more limber reeds vibrate more rapidly and are therefore pitched higher.

Mamma Dolls.—The mechanism is easily removed and studied. A heavy weight falls or slides down a rod when the doll is turned face downward. This weight forces the air out of an air chamber through a small opening, making the sound. The double ma ma sound is produced by a hole in the rod which allows air to escape more freely for an instant at the mid point of the process.

Tricycles.—The feet turn the cranks which turn the front wheel. The tricycle rests on three points and therefore does not fall over easily.

Bicycles.—The feet turn a crank which turns a large cog wheel. A chain from this cog wheel to a smaller cog wheel on the back wheel causes it to turn rapidly. It is necessary to balance one's body from side to side since the bicycle rests on only two points. When moving rapidly, it is easier to balance, as the bicycle tends to continue moving forward in the direction in which it is going more than it does to fall sidewise.

Tops.—Tops are spun by springs, by strings, and by hand. As long as the top is spinning rapidly, it tends to continue its whirling direction more than it does to fall over.

Boats, Floating Birds, Etc.—These toys float because they are lighter than the water that they would have to push out of the way in order to sink. The boats are sometimes propelled by a spring which turns a paddle wheel. This wheel propels the boat forward by pushing back against the water. They are sometimes guided by rudders which can be set at an angle. As the boat goes forward, the water pressing against this rudder pushes the back end of the boat aside and changes its direction.

References

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1933, pp. 119–131.

GARRISON, CHARLOTTE G.: "Permanent Play Materials for Young Children," New York: Charles Scribner's Sons, 1926, 122 pp.

*HALL, A. NEELY: "Homemade Toys for Girls and Boys," Boston: Lothrop, Lee & Shephard Company, 1915, 217 pp.

Household Finance Corporation: "Children's Playthings and Books," Chicago, 1935, 27 pp.

LEONARD, MINNETTA SAMMIS: "Best Toys for Children and Their Selection," Madison, Wisconsin: Wisconsin Kindergarten Association, 1925, 24 pp.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 137–141.

*———, and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 180–190.

*TIPPETT, JAMES S.: "Toys and Toy Makers," New York: Harper & Brothers, 1931, 134 pp.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 158–209.

FINDING THE USES THAT WE MAKE OF SCIENCE

Aims

Realization that scientific study and discovery have revolutionized existence and are our chief hope in the solution of our problems.

Appreciation of the work of scientists and a desire to add to our store of knowledge.

Suggestions

Raise a question as to who uses science most. Lead the discussion to our own use of the discoveries of science.

Let the class compile from observations and discussions at home and at school a list of the ways in which they use the findings of science. The undertaking is so immense that it will be possible to become aware of each field of service only in a general way.

Read and discuss the lives of scientists.

Contributing Learnings

Scientific discoveries have changed almost every phase of existence. Few persons realize in how many ways we use and come to depend upon science.

The homes we live in have become more sanitary, better lighted with natural and artificial light, better heated, insulated, air conditioned, fireproofed, and made more durable. They have better water supplies and furnishings.

Our foods have been improved in countless ways. They are better refrigerated and better cooked by modern methods. Milk and water supplies are safeguarded. Improved varieties of fruits, vegetables, and farm crops have replaced the very inferior varieties found in nature. Better breeds of poultry and livestock have been developed.

Locomotives, fast ocean vessels of various types, automobiles, and aircraft have increased travel and transportation. Without them we should travel little and could have few of the things that they now bring to us.

We have come to depend upon scientific discoveries just as much when we wish to communicate with each other and to keep aware of the outside world. Without the discoveries making possible rapid printing, telephones, telegraphs, and radios, we

should grow up having little contact with any but our immediate neighbors.

We depend to a large extent upon science for our recreation as well. Reading, most of our music, moving pictures, travel, and other pleasures are possible because of scientific discovery.

We are protected from many diseases largely through scientific discoveries in immunizing, in destroying disease carriers, in public sanitation, and in personal hygiene. When we do become ill, a number of scientific means of finding our trouble and treating it are available to us.

The greatest gift of science is the scientific method to guide us. People depend, in almost every phase of life, on the tested works of science, yet most of them do not guide their lives by its method of gathering observational and experimental evidence and weighing it to reach a tentative conclusion. They accept conclusions on the basis of hearsay, authority, or tradition without weighing them against the evidence.

The discoveries that have made possible all of these advantages are the work of many scientists. They are of such great value to us that we ought to provide scientists with everything that they need for their work. Only a few of the many things to learn have been discovered. Some of us may become discoverers of knowledge and render the highest possible service to others.

References

*CRAIG, GERALD S., and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 257–428.

*HURTEBISE, ALIDA: "Inventions: How They Help Us," Columbus: American Education Press, 1935, 36 pp.

*NIDA, WILLIAM L., and STELLA H. NIDA: "Science Readers for Silent Reading," Book V: "Makers of Progress," Boston: D. C. Heath & Company, 1926, 206 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book V. "Science at Home," New York: The Macmillan Company, 1934, pp. 41–423.

*PAYNE, GEORGE E., HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book III, Boston: Benjamin H. Sanborn & Company, 1928, 172 pp.

*———, ———, and ———: "Elementary Science Readers," Book IV, Boston: Benjamin H. Sanborn & Company, 1928, pp. 96–185.

*PHILBRICK, METTA G.: "Magnetism and Electricity," Columbus: American Education Press, 1935, 35 pp.

*REH, FRANK: "Science Related to Life," Books I and II: "Water, Air, Sound, Heat, and Health," New York: American Book Company, 1932, pp. 5–8.

HOLDING OPEN HOUSE AT THE MUSEUM

Aims

Greatly increased ability to find interests in the common objects of the environment.

A desire to share knowledge.

Growth through responsibility.

Suggestions

The museum is not to be exhibited as a finished project at this time, and the open house is decidedly not a "show-off." It is held during the winter quarter to stimulate interest, to give the children an opportunity to assume responsibility, and to acquaint the parents with the undertaking and to enlist their cooperation.

A parent-teacher meeting date is a good day to choose. Invite the parents and the pupils of other grades. Set definite visiting hours. Divide the children into shifts, and let them greet the visitors and explain the exhibit. Many offers will be made by the visitors to contribute articles to the museum. It may be in place here to caution teachers with limited experience in these matters against accepting responsibility for highly valued and perishable articles. Moreover, such articles seldom serve the purpose so well, if we are trying to enable the children to find interest in the common things of their environment.

The museum considerably enlarged will constitute an interesting item of the general exhibit of science activities to be held near the close of school in the spring.

Contributing Learnings

(The information gained will vary with the objects in the collection. It should include the names of the objects, their sources, interesting features, scientific principles and significance, possible uses, etc.)

SPRING SCIENCE ACTIVITIES FOR THE ELEMENTARY SCHOOL

DISCOVERING WHERE ICE AND SNOW LINGER LONGEST

Aims

Interest in the changing season.

Elementary experience contributing to the concept that the sun largely regulates conditions for life on the earth.

Suggestions

Winter in the northern states is a time for enjoying snow and ice, but by February people are looking forward to its disappearance and the coming of spring.

When the first light thaw comes, discover where the snow melts away first. Watch the disappearance of most of the snow during the first general thaw. Note what becomes of the water. When only occasional patches remain, visit these to discover possible reasons why they persist.

Watch the ice go out of the streams. This is one of the beautiful sights of the season. Examine some of the floating cakes of ice to see whether they are carrying anything with them. Compare the disappearance of ice from streams, from ponds, and from lakes. Watch for stoneflies emerging from the water where the ice has parted from the shore.

Discuss what the snow and ice have meant to us during the winter and what will become of the water when they melt. Follow a drop of water in your imagination on its cycle until it returns to us again.

When no more snow and ice are in evidence, dig in the ground in shady places and under heavy grass cover to see whether the ground is still frozen.

Talk about the far north and the high mountain valleys where the ice never entirely disappears.

Contributing Learnings

The snow and ice accumulate in winter when the sun is too far to the south of us to furnish enough heat to melt them away.

Each day now the sun is coming to shine more nearly vertically upon us and is melting the snow and ice. Later it will be almost directly above us, and we shall have summer.

The snow protected the plants during the cold winter. It also broke some of their branches. It made it hard for some of the animals to get food. The snow and ice provided many pleasures for us. Now that the snow is melting away, it is still important, as it will furnish some of the water that the plants will need to start their growth.

When the snow melts gradually, and the ground is not frozen, much of the water sinks into the earth. Sudden thaws of snow and ice when the ground is still frozen fill the valleys with so much water that the streams overflow their banks. Many smaller streams join to make a great sea of water in the larger valleys. Homes may be washed away, and people and animals drowned.

The snow disappears first from dark surfaces exposed to the sun such as roofs, boardwalks, and some streets. Lighter colored objects do not absorb so much heat. Snow disappears last from the north side of buildings and other objects where it is protected from the sun. The sun largely governs things about us. It changes winter to spring.

The ice disappears from streams earlier than from lakes. Soil warms faster than water. Water flowing from the warmer soils helps to melt the ice in the streams. The water from spring thaws raises the water level beneath the ice, thus heaving it and breaking it. The pieces of ice floating down the streams are very beautiful. When they break away from the shore and the bottom of the shallow portions, they often carry with them soil, stones, and even plants and animals. People are carried away at times on large cakes of ice which break loose and float out while they are busily engaged in fishing. The ice disappears last from the lakes, for here the sun must gradually melt it away. In the northernmost part of our country, some ice remains in the lakes until June.

Much farther north some ice remains throughout the summer. This is also true in the valleys of high mountains. The ice spreads out from these areas, but it melts back at the edges about as rapidly as it moves. Only if the climate of the earth became colder could glaciers come down over our region of the earth again as they have done at times in the past.

References

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 100–109.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 118–124.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 124–129.

DISCOVERING SIGNS OF SPRING

Aims

Joy in discovery. Interest in the coming of the spring season.

Experience contributing to the concept that the sun largely regulates conditions on the earth and that changes are due to natural causes.

Suggestions

This activity may well take the form of a game for "sharp eyes." It is necessary to begin very early.

Some method of keeping the discoveries before the attention of the children should be devised. Specimens, pictures, and written records may be used. Each should be dated and bear the name of the observer. A "sign-of-spring" bulletin board is excellent.

Some of the many discoveries likely to be reported and discussed are snow melting, warm day, first game of marbles out-of-doors, streams and lakes open, first boat, flocks of wild birds flying northward, tender green blades of grass, dandelion in bloom, insects flying or crawling about, horned larks, bluebirds, robins, and other birds returned, snake out sunning itself, frogs croaking, buds swelling, shrubs and trees in bloom, house cleaning, cleaning yards, plowing or other preparations for planting, planting, new plants appearing, taking off storm windows, people outdoors without outer wraps, spring flowers, and swollen streams.

Build enjoyment in anticipating the spring season through poetry, games, field trips, and discussions.

Contributing Learnings

During the winter the sun is far to the south of us. The slanting rays of the sun do not warm the earth so much as if the sun shone more nearly vertically down upon us.

Late in winter the rays are less slanting, and they begin to warm the earth more each day. This added heat brings about many changes.

It melts the snow and ice, giving water to the soil and streams. Boats can travel again. We put away our sleds and skates.

The sun warms the earth and enables the plants to begin their growth. Seeds germinate. The sap rises. Buds swell. The plants begin to flower and leaf.

Animals must be warm inside to be active. Frogs, snakes, insects, and most other animals become cold and still during winter. The heat makes them active again.

Now the birds begin to come back from the southland and are able to find insect and plant food. Water birds return to the open water.

The increasing heat of the sun causes us to make many changes. We put on lighter clothing, remove storm windows from our homes, and begin our spring cleanup. We hasten to get our soil ready for early planting.

The sun causes many changes on the earth. We depend on the sun so much that many peoples worshiped it. It makes life possible and largely controls conditions on the earth.

References

*Alder, Grace: "The Seasons," Columbus: American Education Press, 1935, 36 pp.

*Beauchamp, Wilbur L., Gertrude Crampton, and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 7–10.

Beebe, Charles William: "The Log of the Sun, A Chronicle of Nature's Year," Garden City, New York: Garden City Publishing Company, 1906, pp. 33–98.

**Cornell Rural School Leaflet*, Vol. 23, No. 2: Through the Year, Ithaca, New York: Cornell University, November, 1929.

Howes, Paul Griswold: "Backyard Exploration," Garden City, New York: Doubleday, Doran & Company, Inc., 1927, pp. 18–27.

Johnson, Gaylord: "Nature's Program," New York: Doubleday, Doran & Company, Inc., 1926, pp. 1–66.

Maryland School Bulletin: Science in the Elementary School, Baltimore: State Department of Education, 1933, pp. 26–29.

Pack, Arthur Newton, and E. Lawrence Palmer: "The Nature Almanac," Washington, D. C.: The American Nature Association, 1927, pp. 8–17.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 103–153.

Sharp, Dallas Lore: "The Spring of the Year," Boston: Houghton Mifflin Company, 1909, 148 pp.

KEEPING A SPRING WEATHER CALENDAR

Aims

Interest in the changing season.

Experience contributing to the concept of the controlling influence of climate and the natural causes of seasonal changes.

A more scientific attitude toward weather lore.

Suggestions

Make or procure a very large calendar. Select suitable symbols for sunny, cloudy, rainy, and snowy days. Let children color the calendar to show the weather each day or make paper cutouts from colored paper to paste on it. The following symbols are sometime used:

For Cloudy Days.—Color gray, or paste on wavy bands cut from dark-gray paper.

For Sunny Days.—Color blue, or paste on yellow paper cutouts of the sun, or use both.

For Rain.—Streak, stipple, spatter, or paste on umbrella cutouts.

For Snow.—Leave plain white, or draw snowmen.

If the weather varies during the day, the conditions can be represented by combinations of the foregoing symbols. Half of the square may be colored yellow, and the other half gray. Alternate sun and shade may be shown by streaks of yellow and gray, etc. Various methods of representing variable weather will suggest themselves to teacher and pupils.

Each day at the same hour or hours the pupils should read the outdoor thermometer and record the temperature on the calendar. At the same time read and record the wind direction. If a marked change of temperature or wind direction occurs during the day, enter more than one record in the square.

Reserve a space on the calendar each day for recording seasonal observations and events.

Compare each week and each month's calendar with previous ones. Note especially the changes in temperature and the corresponding observational records of seasonal changes.

If calendars have been kept by preceding classes, it will prove very interesting to compare the present season with previous ones.

Contributing Learnings

Changes in spring weather are frequent. Sun and shade, storm and clear weather, warm and cold are surprisingly intermingled.

The temperature varies considerably from day to day with the changes of the wind and of the amount of moisture in the air, but by comparing with previous weeks we discover that it is gradually rising. The added heat on the earth brings about many changes. Thaws come; plants grow; and animals emerge from their winter sleep. Each change takes place when enough heat has accumulated to bring it about.

The winds are usually from the west. They bring us a series of alternating periods of unsettled and fair weather. Each period commonly lasts only a few days.

There is some variation in the seasons from year to year, but the records that we keep show that they are more alike than most people think they are. We notice any unusual weather and imagine that the whole season is different. We can depend upon the records of events in nature and disregard the superstitions that people hold about the weather. Some weather lore is based on truth.

The seasonal changes govern the activities of plants and in large measure determine those of animals. They influence our lives in very important ways.

References

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 47–51.

*———, HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 18–41.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 97–129.

FREE, E. E., and TRAVIS HOKE: "Weather," New York: Robert M. McBride & Company, 1928, 337 pp.

PAYNE, FRANK OWEN: "One Hundred Lessons in Nature Study," Chicago: Beckley-Cardy Company, pp. 193–199.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 131–136.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 239–253.

VAN CLEEF, EUGENE: "The Story of the Weather," New York: D. Appleton-Century Company, Inc., 1929, 263 pp.

SETTING UP A HOMECOMER'S GALLERY

Aims

Greater enjoyment of bird life. An alluring outdoor interest and means of satisfaction which tends to carry over into leisure hours throughout life.

Experience that makes for attitudes of appreciation and conservation of bird life.

Suggestions

Talk over the common birds which soon may be expected to return from the south. Hunt out their pictures. Under a suitable caption, such as "Arrivals Expected," post the pictures of the birds that are likely to arrive soon.

In addition, plan a picture gallery of "Homecomers" to which the pictures are to be transferred when the birds arrive. If no bulletin board is available, one can be made from the side of a large carton.

Interest the children in keeping a sharp lookout for birds, but hang each picture in the gallery only after the group as a whole has verified the report of the bird's arrival. This requires class field trips at intervals throughout the spring. Morning is the best time for these trips.

Dates of arrival may be recorded. Some primary teachers arrange the birds by the week or month in which they are first observed.

Describe the new arrivals. Note whether they seem to find their new surroundings strange or already feel at home. Observe their activities. Are they already in pairs? Learn to distinguish male and female. Note when they begin to nest. Plan other bird projects.

Each school should have a set of bird pictures. They can be obtained from a number of sources. See the references for lists of bird pictures available.

Contributing Learnings

Many birds fly long distances to the south in the fall and early winter, returning in the spring. We do not know why they do

this. Their movements seem to depend partly upon the food supply.

When we travel we have maps and guides. We stop often to inquire our way. How birds can find their way on these long flights is one of the most interesting mysteries. By banding the birds so that we can recognize them again, we have found that many journey hundreds of miles to the southland and find their way back to the same nests in our yards that they occupied the previous season.

They begin to arrive from the south in late winter before the snow is gone. The first birds to arrive are kinds that spend the winter not far to the south of us. The date of their arrival varies in different seasons with the earliness or lateness of the spring. The others, having spent the winter too far to the southward to be affected by the weather in this part of the country, arrive about the same time each year.

The horned larks arrive first in the northern states during February. Soon crows become abundant (a few crows remain here during the winter).

March brings the robins, bluebirds, killdeers, meadow larks, blackbirds, juncos, ducks, geese, and a few others.

The warblers, swallows, chimney swifts, martins, wrens, and more of the water birds appear during April. By this time robins and bluebirds are nesting. Unless the first eggs have been frozen, killdeers are already hatched. There are young owls now.

May is the most interesting bird season. Most of our feathered friends have arrived, and many of them are homemaking. The air is full of bird music, and the bright colors of the birds are seen everywhere about us. Watching for the birds to return has become a hobby with many people. The arrival of the first robin and bluebird is published in the newspapers. People hail this event with joy. It means that spring is here again.

References

American Nature Association, Washington, D. C. Bird pictures.

*ATHEY, LILLIAN COX: "Along Nature's Trails," New York: American Book Company, 1936, pp. 103–158.

BALL, ALICE E.: "Bird Biographies," New York: Dodd, Mead & Company, Inc., 1927, 291 pp.

*BOULTON, RUDYARD: "Traveling with the Birds," New York: M. A. Donohue and Company, 1933, 64 pp.

George P. Brown and Company, Beverly, Massachusetts. Bird pictures.

*Chapman, Frank M.: "The Travels of Birds," New York: D. Appleton-Century Company, Inc., 1916, 158 pp.

*Craig, Gerald S., and Margaret G. Condry: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 17–43.

**Cornell Rural School Leaflet*, Vol. 22, No. 4: A Travelog of Birds, Ithaca, New York: Cornell University, March, 1929.

*Dunn, Fannie Wyche, and Eleanor Troxell: "Mother Nature Series," Book III: "In Field and Forest," New York: Row, Peterson & Company, 1928, pp. 189–208.

*Eaton, Elon Howard: Birds of New York, *Memoir* 12, New York State Museum, Albany, New York: University of the State of New York, 1910, 2 vols., also separate color plates.

*Mathews, F. Schuyler: "The Book of Birds for Young People," New York: G. P. Putnam's Sons, 1921, pp. 1–185.

National Association of Audubon Societies, 1974 Broadway, New York City. Bird pictures.

Perry Pictures Company, Malden, Massachusetts. Bird pictures.

*Persing, Ellis C., and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 209–218.

*——— and John A. Hollinger: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 218–225.

*Roberts, Thomas S.: "Birds of Minnesota," Minneapolis: University of Minnesota Press, 1932, 2 vols.

*———: "Bird Portraits in Color," Minneapolis: University of Minnesota Press, 1934, also separate color plates.

*Trafton, Gilbert H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 282–287.

OBSERVING AND REPORTING NEW LIFE

Aims

Desirable attitudes toward reproduction.

Some realization that reproduction plays a leading role in the lives of plants and animals. Experience contributing to the concept of overproduction and the balance of life.

New avenues of observation and satisfaction.

Suggestions

Begin in March before many young have appeared. To interest the children in observing new plants as well as animals, let them plant a variety of seeds where they can watch the development. Roll a dark blotter, and place it in a glass jar. Arrange the seeds between the blotter and the glass. Coil some springy twigs in the center to hold the blotter firmly against the glass so that the seeds will stay in place, or fill the jar with sand or sawdust. Pour a little water into the jar. The water will rise in the blotter and keep the seeds moist. The growth of the baby plants can be easily observed and compared.

Study the development of any available baby animals. Secure them as soon after birth as possible. Rabbits, kittens, baby chicks, insects, or any other animals will do. If any guppies are kept in the aquarium, they will serve the purpose. Observe and describe the development of the baby animals.

When interest has been aroused, children will be eagerly on the lookout for plant and animal babies of all kinds. It is a good plan to reserve a space for displaying pictures of all the kinds of young that are discovered. If no pictures of the young plants can be found, children can draw them.

Feature new life of all kinds—young farm animals and pets, wild animals, poultry and wild birds, fishes, tadpoles, insects, spiders, farm and garden crops, cultivated and wild flowers, tree seedlings, weeds, etc.

Describe and discuss the young. Note how they differ from the mature forms. Observe what care any of them may receive. How soon are they able to care for themselves? Make comparison with human babies.

Compare the number of young with the number of mature animals and plants of the same kind.

Compare the habits of the young of other animals with those of human infants. List the babies that hatch from eggs that have been laid and those which are born alive.

Use poems, songs, and many pictures to arouse further interests in new life and to create attitudes toward nature's babies. Let the children write and tell the stories of the development of some of the new babies.

Contributing Learnings

Spring is not only the time when most plants and animals increase their activities, but it is also interesting because of the new life appearing all about us. Most of these new lives were started in or on the parent animals and plants long before spring —many of them the previous season. But now they come to live separate lives, and we notice them for the first time.

Most of the new plants appearing have come from seeds. Each seed contained enough food to enable the plant to develop roots and to push its shoot through the ground. Soon after it appears aboveground, new leaves develop, and it is able to make its own food. Some plants even bring the old halves of the seed above the ground and use them for leaves until true leaves are formed.

Some new plants come from roots, stems, and other parts of the parent plants. Many of the plants that appear so quickly in the spring are only new tops, the underground parts having lived through the winter.

Many animals, such as birds, snakes, turtles, frogs, toads, most fishes, most insects, and spiders, lay eggs containing enough food for the developing babies until the latter break the shell and come forth.

In other animals the eggs develop inside the mother, and the babies are born about as developed as those which hatch from eggs.

Many baby animals when first hatched or born begin almost immediately to feed and take care of themselves. Some of the birds and the hairy animals are rather helpless babes, but they grow rapidly and learn to care for themselves much earlier than we do.

Some of the baby plants have only one parent, having come from a root or bud of the old plant. Most plants and all of the higher animals have two parents. One parent produces the eggs which grow into the baby animals or plants. The other parent produces the sperms without which the eggs cannot develop.

Babies are interesting creatures. Their helplessness seems to make them more interesting to us. Then there is always the joy in watching them change and develop. (The development of the different animals requires too much space to describe to be included in this brief statement of outcomes.)

References

*AGNEW, KATE E., and MARGARET CABLE: "Baby Animals on the Farm," Yonkers-on-Hudson, New York: World Book Company, 1933, 153 pp.

*BEATTY, JOHN Y.: "Story Pictures of Farm Animals," Chicago: Beckley-Cardy Company, 1934, 155 pp.

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 60–73.

**Cornell Rural School Leaflet*, Vol. 27, No. 4: New Life, Ithaca, New York: Cornell University, March, 1934.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 191–200.

*——— and ———: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 143–184.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book III: "In Field and Forest," New York: Row, Peterson & Company, 1928, pp. 53–62, 105–144, 169–188, 200–257.

*GORDON, EVA L., and JENNIE HALL: "Nature Stories for Children—A Spring Book," New York: Mentzer, Bush & Company, 1927, 90 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book III "Surprises," New York: The Macmillan Company, 1933, pp. 115–121.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc. 1930, pp. 85–113.

*TORELLE, ELLEN: "Plant and Animal Children," Boston: D. C. Heath & Company, 1912, 230 pp.

*TROXELL, ELEANOR, and FANNIE WYCHE DUNN: "Mother Nature Series," Book I: "Baby Animals," New York: Row, Peterson & Company, 1928, 160 pp.

GROWING TINY PLANTS AND ANIMALS

Aims

A new field of interest and enjoyment which many people have never come to know.

A saner attitude toward the so-called "germs" of the microscopic world and a more intelligent basis for establishing important habits of sanitation.

A better concept of the amount of life on earth, of the pyramid of numbers, and of the balance of life. Experience contributing to the concept that continuous existence on the earth is made possible by recurring cycles of synthesis and decomposition.

Suggestions

Bring in an orange on which blue mold (*Penicillium*) is growing. Show the children its pretty blue and green colors, and interest them in growing a crop of the mold. Experiment to find out on what substances it will grow. Sow the spores of the mold on a variety of objects—bread, paper, wood, cloth, fruits, vegetables, soil, stones, nails, etc. Two glass dinner plates put together to make a covered dish form an excellent moist chamber for growing molds and fungi.

Make a trip to a stagnant pond or pool to see who can find the most tiny forms of life there. Bring back a vessel of water containing some small sticks and stones found in the bottom of the pond, a little of the ooze or mud, and some pond scum. Put the water in an aquarium, and watch for signs of life. If possible, borrow a microscope, and view the great array of minute forms of plant and animal life.

Let the children grow these tiny plants and animals in individual aquariums. Any small glass containers will do. Fill the aquariums with clear water. Cook a handful of rice or a small amount of hay in a vessel of water. Cool and add a little of the water to each aquarium to provide food for the tiny creatures. Then, using a medicine dropper, transfer a few of the forms of life from the pond-water aquarium to the smaller aquariums.

Read the story of bread making to the children, and talk about the life in a cake of yeast. Stir a cake of yeast in a little potato

water, and keep it in a warm place to let the yeast plants grow. Look for the budding yeast plants under the microscope.

Find out and tell how bread is made at home. Make a little sauerkraut and vinegar at school. Let cream ripen, and churn the butter.

To find out whether there are tiny forms of life on almost all kinds of objects, bring in a handful of dry grass, and put it in a vessel of clear water. After a few days, note the myriad of tiny white animals just barely visible to the eye. By adding some water in which grasses have been boiled for a time, an even richer crop of animals can be grown. Some of the largest of the bacteria will also develop in the culture. Help the children to see these through the microscope.

Prepare some gelatin or agar, using rice water. It is not necessary to sterilize it. Pour it into shallow glass vessels, and let it harden. Let the children plant bacteria, yeasts, and molds on it in any way that they choose. Cover so that the medium will not dry out too much, and keep in a reasonably warm place. Look at the colonies the next day. Set the dish on the stage of the microscope, and examine with the low power. Notice that each colony consists of an immense number of organisms.

Talk about the tiny plants and animals, where they live, whether they are all "germs," how numerous they are, and how soon a new generation grows.

Contributing Learnings

There is a part of the living world that most people never see. There are more of these creatures than of the larger ones. They are as real as any other plants and animals. They feed, grow, increase in numbers, and many of them move about, but they are very tiny. Many of them cannot be seen without a microscope.

The tiny plants and animals are to be found almost everywhere. When we take a walk we may see a number of trees and larger animals, but we are passing millions of tiny plants and animals every step we take. They are in the soil, on objects, on and in plants and animals, in the water, and even on the dust in the air.

Many people call these tiny forms of life "germs," meaning disease causers. This is because they do not know these little beings so well as they do the larger ones. A few of them do cause diseases of people and of other animals and plants. Some larger plants and animals such as poison ivy and rattlesnakes also

make us ill, but we are not afraid of all plants and animals because a few of them are harmful.

Some of these little creatures are very valuable. Plants and animals use the materials of the soil and air as they grow. After they die, the tiny forms of life live on them, breaking down the plant and animal bodies and returning the materials to the soil and air again so that more plants and animals can use them in their growth. The tiny water plants and animals serve as food for larger forms.

Tiny plants cause the bread to rise, make vinegar out of fruit juices, and make sauerkraut out of cabbage. They ripen the cream, give flavor to butter, and make cheese. They ret the flax out of which we make linen and help in tanning hides to make leather. Certain kinds of them are necessary for the best growth of our crop plants.

The tiny animals make the sand filters of the water purification plant better strainers to clean the water. Chalk is largely formed of the shells of very small ocean animals. These animals have formed many islands.

When we come to know these little plant and animal creatures who are such good farmers and the makers of so many useful things, we no longer think of them as enemies. It is true that in living their lives a few of them would make us ill if they ever started to grow in us. If we avoid sick people and food and water that might have received the tiny disease plants or animals from sick persons, we do not need to worry about other unseen forms of life. Most of those that do cause disease enter our bodies through the mouth or nose.

We keep clean and keep our hands away from our mouths and noses so that we shall not carry into our bodies any disease plants or animals that happen to be on our hands.

The tiny plants and animals increase very rapidly. From one tiny plant, millions may develop in less than a day. When we think how slowly trees and people increase, it does not seem strange that there are more of the little creatures than of larger plants and animals.

Many of the tiny plants and animals have another way of spreading over the earth and living through bad times. When the water in a pond dries away, the little creatures form a firm wall around themselves. They can live slowly and quietly in this condition for months. The wind blows many of them

about, and they land everywhere. This is how tiny creatures got into the jars when we placed dry grasses in water.

References

*CHAMBERS, MARY D.: "Nature Secrets," Boston: Little, Brown & Company, 1923, pp. 17–33.

**Cornell Rural School Leaflet*, Vol. 21, No. 2: Fungi, Ithaca, New York: Cornell University, November, 1927.

*CRAIG, GERALD S., and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 387–421.

*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 133–139.

"Protozoa," Chicago: General Biological Supply House.

PARKER, BERTHA MORRIS, and HENRY CHANDLER COWES: "The Book of Plants," Boston: Houghton Mifflin Company, 1925, pp. 52–92.

*PAYNE, GEORGE E., HENRY R. BARROWS, and LOUIS J. SCHMERBER: "Elementary Science Readers," Book II, Boston: Benjamin H. Sanborn & Company, 1927, pp. 171–200.

*———, ———, and ———: "Elementary Science Readers," Book III, Boston: Benjamin H. Sanborn & Company, 1928, pp. 109–163.

*PERSING, ELLIS C., and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 260–268.

MAKING A WILD-FLOWER GALLERY

Aims

Interest in wild flowers which provides enjoyment and leads to conservation.

Simple experience contributing to the concept of survival through adaptation and of interrelations of living things.

Suggestions

Secure a set of colored pictures of the common wild flowers. (A set of 264 beautiful color plates is obtainable at cost from the New York State Museum at Albany, New York.) Provide a bulletin-board space in the room or hall.

Early in March look over the flower plates, and select those of the most familiar spring flowers. Watch for these flowers to appear. As each comes into bloom, post the picture in the gallery. Below each picture record the date.

Each flower face tells a story, and many of these stories are simple enough to be studied in the lower grades (see the Contributing Learnings). The teacher should go only as far into these stories as the interest and ability of the children will carry them, but this is much farther than is commonly supposed.

Note the plan that each flower type has developed. Examine the arrangements for pollination, noting what each flower offers to insects in the way of attraction. Find the pollen and the pistil where the seeds will develop.

Observe the insects visiting the flowers, and discover how they distribute the pollen while getting the nectar. In the gallery, post pictures or a list of insects about each flower plate.

Become familiar with the flower faces. Note what makes each so beautiful and interesting.

Without pulling the plants, scrape the root of a bloodroot plant, and see the dye with which Indians sometimes used to paint their bodies. Rub the root of wild ginger, and note the strong but pleasant odor of ginger. Find the clusters of corms at the bases of squirrel corn and Dutchman's-breeches, which serve to multiply the plants. Examine other wild flowers for underground storage regions.

Contributing Learnings

Many wild flowers appear early in spring before the trees and tall growing herbs shade them. Most of them stored food in underground regions the year before and are able to bloom earlier than plants starting from seeds.

Skunk cabbage is about the earliest wild plant to bloom. We do not like its odor, but the early-appearing flies seem to find it attractive.

April usually brings the buttercup, pasqueflower, bloodroot, and hepatica. Dogtooth violets, Dutchman's-breeches, spring beauties, violets, bellworts, and trilliums follow.

Each kind of flower has a beauty of its own and a face that tells its story of pollination. Most plants depend upon seed babies to continue their kind on the earth and, if they are not pollinated, soon lose out in nature.

Plants have been changing for a very long time, and many new arrangements for producing baby plants have appeared. Most of the plants that we find today have some attraction for insects. These attractions consist of signboards in the way of showy petals, nectar with a strong odor stored deep in the flower where insects must pass the pollen and sticky top of the pistil to reach it, lips which serve as landing fields for insects, and many other arrangements.

Insects, too, have developed many arrangements for securing the nectar and pollen, such as long tongues and sucking tubes and pollen baskets.

Some flowers, such as Dutchman's-breeches and squirrel corn, remain closed about the stamens and pistil and must be self-pollinated.

The arrangements for pollination give each kind of flower a style and beauty different from the others. When we come to know and understand the flower faces, they become even more interesting, and we dislike to see these beautiful products of nature's experiments destroyed.

Many flowers such as adder's-tongue (dogtooth violet) and yellow-eyed grass are lily-like. The parts are arranged in threes or multiples of three.

Even more of the fiowers have their parts in fives. Such flowers are wild geranium, chickweeds, violets, spring beauties,

etc. Mustards (including rock cress and shepherd's-purse), bluets, and a few other flowers are in fours.

Some flowers are open-faced, with all petals separate. The simplest and oldest flowers are mostly open-faced types with many stamens and pistils. They are quite variable as to number of petals, sepals, stamens, and pistils. And with all of their stamens and pistils, they do not seem to produce any more seed babies than do some of the flowers with fewer of these parts. Buttercups and anemones are good examples.

In many flowers the petals are joined in a tube. Insects must brush past the stamens and pistils in reaching the nectar. Phloxes and morning-glories are common examples.

Irregular flowers such as snapdragons and mints furnish landing fields for insects. Spurs of larkspur and columbine contain nectar.

Dandelions and many of the summer- and fall-blooming plants produce many tiny flowers clustered in a head on a single stem. This seems to have been one of the most successful ways to produce seeds, judging by the way in which these plants have spread over the earth, although this may be due in part to their flyaway seeds and other advantages.

Plants show by their flower faces which are close relatives, as people sometimes do.

References

BLANCHAN, NELTZE: "Wild Flowers Worth Knowing," Garden City, New York: Doubleday, Doran & Company, Inc., 1923, 270 pp.

CLEMENTS, F. E., and E. S. CLEMENTS: "Flower Families and Ancestors," New York: H. W. Wilson Company, 1928, 156 pp.

DURAND, HERBERT: "My Wild Flower Garden," New York: G. P. Putnam's Sons, 1927, 242 pp.

*HOUSE, HOMER D.: "Wild Flowers," New York: The Macmillan Company, 1934, 362 pp.

*———: Wild Flowers of New York, *Memoir* 15, Albany, New York: University of the State of New York, 1923, 362 pp.

*———: Color plates (264) from *Memoir* 15, Albany, New York: University of the State of New York, 1923.

KEELER, HARRIET L.: "Our Early Wild Flowers," New York: Charles Scribner's Sons, 1931, 252 pp.

*MATHEWS, F. SCHUYLER: "The Book of Wild Flowers for Young People," New York: G. P. Putnam's Sons, 1923, pp. 3–122.

*"The Book of Wild Flowers," Washington, D. C.: The National Geographic Society, 1933, 243 pp.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 135–138, 145–150.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 202–207.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 172–178.

*——— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 248–254.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 269–279.

REED, CHESTER ALBERT: "Flower Guide: Wild Flowers East of the Rockies," Garden City, New York: Doubleday, Doran & Company, Inc., 1922, 232 pp.

EXPLORING BY SOUND AND TOUCH

Aims

Greater awareness of the environment and satisfaction through increased use of the senses of sound and touch.

Some appreciation of the importance of the senses, and consideration for the handicapped.

Suggestions

Have the children close their eyes while you carry on some activity about the schoolroom. Let the children guess what you did. Let a child carry on some other act while the remainder of you listen with eyes closed to guess it. Vary this game by using the sense of touch. Place objects in the hands of the children to guess. Pass objects down the line, and give each child a guess. Let the children move about with eyes closed identifying by touch the objects encountered. Move slowly to avoid accident and injury. Try to introduce sounds and objects that the others cannot recognize.

Ask the children whether they would like to explore the out-of-doors by sight and sound. Select a good comfortable place out-of-doors, and remain quiet with eyes closed. Describe the activities going on in the world about you as judged by the sounds that you hear. Play the game a number of times, preferably at different hours of the day, to become familiar with a wide range of activities in this manner. Have the children play the game at home after dark and report the night activities.

Each commonly heard sound suggests a story to tell of interesting activities going on about us. Some of these sounds are:

Dingdong of school, church, or locomotive bells.

Blowing of automobile horns.

Ripping sound of tires on pavement.

Sound of motors starting and purring along smoothly.

Siren and clang of fire trucks.

Bumping and clanging of street cars.

The chug-chug of the trains.

Blowing of factory whistles.

Firing of guns.

Cries of newsboys and street peddlers.
Footfalls of different people.
Barking of different dogs and their sounds while engaged in the chase.
Neighing of horses.
Lowing of cattle.
Bleating of sheep.
Braying of donkeys.
Crowing of roosters and cackling of hens.
Cluck of mother hen and peep of baby chicks.
Mewing and spitting sound of cats.
Chattering of squirrels.
Croaking and piping of frogs.
Caw of crows.
Rap-a-tap-tap of the woodpeckers.
"Bobwhite" whistle, "jay" scream and "tular" cry of the blue jay, "killdeer" cry, chirping of the English sparrow, "chickadee" song.
Hum of insects.
Murmur of the stream and sound of the falls.
Rushing and sighing of the wind.
Voices, differing with age, sex, and mood of individuals.
Opening and closing of doors and windows.
Noises of play and work.

Play the game of recognition by touch out-of-doors by leading blindfolded persons to various objects. Do not have children go about blindfolded except under close supervision. Otherwise accidents may result.

Talk about the different ways in which we may learn about the world. Discuss how people deprived of sight learn to interpret and enjoy things. Discuss also what we should miss without sight and how we care for our eyes.

Contributing Learnings

There are many ways of learning to know and enjoy the interesting world about us. Perhaps the most important is sight. Without sight we could not enjoy the beautiful colors and forms of things. We could not drive about and enjoy travel as we do. We should also be in danger many times where our sight now saves us.

Blind people do learn to find their way about by touch and to know what is happening in most cases through sound. They can enjoy music, can read by touch, and can talk to others. Many of them go about with occasional help. We should help them to cross streets and to find places whenever we can.

We depend upon sound in many ways. Sounds warn us of approaching dangers, help to locate lost persons, express our joy and sorrow, help us to understand and enjoy our companions, and afford a means of finding happiness in our surroundings.

Touch also tells us much. We touch many things carefully at first to test them. We must have a fine sense of touch as well as of sound to play a musical instrument. We depend upon touch to find and recognize objects in the dark.

Both sound and touch can express fine shades of meaning. A dog understands many of the sounds that we make, though he does not know our language. Snakes and many other animals respond to a gentle touch by showing no fear, where they would otherwise struggle and possibly bite us.

Each object has its feel to our touch, and each sound its meaning to us.

Anything that disturbs the air causes waves of it to strike our inner ears and affect the delicate nerves causing us to hear a sound. That is why so many of the things going on about us tell their story to us through sound.

Sight, hearing, and touch are more important to us than taste and smell. We should take the best care of eyes and ears. This means that we should wear our glasses if we need them, should not read in poor light, and should not strike anyone about the eyes or ears even in play. It also means that we should stay home when we have colds, should not blow our noses hard or use nasal washes and thus avoid infecting the middle-ear, and should report to teacher or parent any earaches or running ears.

References

BRAGG, WILLIAM: "The World of Sound," London: George Bell & Sons, Ltd., 1930, 196 pp.

*Cornell Rural School Leaflet, Vol. 27, No. 3: Sound, Ithaca, New York: Cornell University, January, 1934.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 103–115.

SHARP, DALLAS LORE: "The Year Out of Doors," Boston: Houghton Mifflin Company, 1914, pp. 59–66.

OBSERVING THE HAPPENINGS ON WINDY DAYS

Aims

Interest in the wind and its effects.

Added realization of the dependence of living things on the environment. Contribution to the concept that natural forces alter the surface of the earth.

Awareness of the problem of harnessing energy and of the need for conserving soil and power resources.

Suggestions

Choose any very windy March or April day to begin the study. Continue thereafter as opportunity permits until satisfaction has been achieved. Make field trips to discover what changes the wind is making. Also, let the children report their observations made at other times. One successful field trip may be sufficient to stimulate a very large amount of individual observation.

Of the large number of possible observations of the work of the wind, the following are among the ones most commonly observed and reported:

Blows dust in our eyes.
Sweeps some places clear.
Piles dirt in queer shapes.
Scatters pollen.
Turns windmills to pump water and do other work.
Litters our yard and schoolyard with papers and trash.
Makes us chase our hats.
Scatters last year's leaves.
Makes waves on the water.
Scatters seeds to new homes to start baby plants.
Makes the clouds move rapidly.
Brings rains, dry air, hot and cold weather.
Breaks branches and blows trees over.
Blows insects about and hinders birds in their flight.
Makes it harder for us to walk and to breathe.
Chaps our skin.
Dries the clothes on the line.
Blows smoke toward some houses.
Blows fire about and scatters it.

Blows rain in through raised windows.
Dries wet streets and roads.
Scatters papers from our desks.
Slams doors and breaks panes of glass.
Flies kites or blows them about.
Whirlwinds take up objects.

Talk about all of the ways in which wind influences us. Fly kites. Dry clothes in the wind and in sheltered places. Sail small boats. Make paper windmills. Fasten sheets of fly paper on boards. Lay them on the ground in windy places, and discover what they collect. Note especially the wind-blown deposits of soil.

Contributing Learnings

Winds carry moisture and largely control the rainfall which we must have in order to grow things.

Winds occasionally become so strong as to destroy trees and buildings. Ships are blown from their course and are sometimes wrecked at sea. At times many lives are lost during high winds.

The winds blow the dry soil about. In this way the loose soil is swept from some places and piled deep in others. Great deposits of soil have formed in this way. Many good farms have been ruined in this way. One section of our country has been called the "Dust Bowl." Plants help to keep the soil from blowing about. Some soil should not be cultivated.

The wind scatters pollen which is necessary to form seeds. It also spreads many plants over the earth by carrying the seeds.

The wind interferes with the flight of small winged animals such as insects and birds. It also hinders travel by airplane and airship at times, sometimes causing accidents.

When the wind blows over a wet surface, it takes up some of the moisture. In this way it dries our clothing and muddy roads. It often takes away so much moisture from the soil and the leaves that the plants wilt. Moisture taken up by the air is dropped elsewhere as rain. In this way we receive rain, though we live far from the ocean.

Wind makes the fire burn more freely. It also blows burning pieces about and spreads the fire.

We can use the wind to do much of our work. The wind turns the windmill. To the windmill we hitch our pumps, feed

grinders, washing machines, etc. Wind power is free, and we do not need to worry about running out of wind.

Winds are very important to us, but we have not learned to control them.

References

*Beauchamp, Wilbur L., Gertrude Crampton, and William S. Gray: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 35–40.

*———, Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 7–23.

*Craig, Gerald S., and Agnes Burke: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 59–86.

——— and Sara E. Baldwin: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 120–129.

*——— and ———: "Pathways in Science," Book III: "Our Wide, Wide World," Boston: Ginn and Company, 1932, pp. 257–284.

*——— and Beatrice Davis Hurley: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 105–119.

*Persing, Ellis C., and Elizabeth K. Peeples: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 81–84.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 131–136.

*——— and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1929, pp. 179–201.

OBSERVING THE EFFECTS OF AN APRIL SHOWER

Aims

Enjoyment of rain.

Experience contributing to the concept of the dependence of living things on water. Background experience for understanding the cycles of water, the problem of erosion, and the role of vegetation in holding soil in place.

Suggestions

Watch the raindrops during an April shower.

Catch raindrops in a cylindrical tin bucket to find how much rain falls if you have not made a rain gauge.

Listen to the noises that the raindrops make striking the roof, windowpanes, ground, walk, and various other objects.

See how long it takes the raindrops to wet all of the surface of the walk.

Find how soon the water begins to drip and finally to run from roofs.

Find how long the treetops make good shelters. Look for sheltered places about buildings and tree trunks not wet by raindrops.

Observe the raindrops striking the ground. How soon and where are puddles formed? See where the raindrops sink into the ground and where they very quickly run off. Allow some of the children with raincoats to trace the course of some of the rills. Consider what will become of the water that sinks in and of that which runs off. Think how each part may help, hinder, or endanger people. Discuss what may become of the water taken up by the air in the process of drying the earth after the rain.

Note the clean, shiny appearance of plants during the shower. Bring the potted plants from the schoolroom for a wash in the rain.

Note that the raindrops are washing dust from walls, windows, slides, swings, fences, and other objects.

Watch and listen for squirrels and birds during the shower and afterward.

See which kinds of work continue and which are interrupted by the rain.

When the rain ceases to fall, make a class excursion to see what effects it has had.

Note how fresh the air seems since the raindrops have cooled it and washed it clean of dust.

Look for earthworms which have come to the surface and are crawling about even in the streets.

Observe whether the roads are slick or muddy.

Visit a small stream, and note how much it has changed. See what the rushing water is carrying with it.

Dig in a garden or field to see how far the water penetrated. See whether it reached the depth at which the vegetables or crop plants will spread most of their roots.

Look for places where soil has been washed away or deposited by the shower. Discover whether the soil came from grassy or bare areas.

Contributing Learnings

The air blowing over oceans, lakes, and wet soil takes up moisture. The winds carry this moisture for long distances.

When a great many tiny droplets of moisture collect in the air, they form clouds.

Sometimes raindrops are small. At other times many of them go together to form huge drops.

We depend upon the rain in many ways. It furnishes the moisture for our plants. More plants are stunted or die from lack of water than from any other cause. The rain also supplies water for our wells, lakes, and streams. It lays the dust and washes things clean. All animals must have water, although some of them get enough from the plants that they eat.

Rains also cause us some problems. They sometimes wash out roads and bridges. If the streams cannot carry away the rain as rapidly as it falls, the lowlands become flooded, and much damage is done.

Much of the water sinks into the ground during a shower. Some of this is taken up by plants, some by winds, and some sinks deeper into the earth. In a few days another shower is needed.

A shower is a very interesting event in nature. Birds sing freely. Squirrels chatter and frisk about. Frogs and toads

make no attempt to seek shelter. Their skins need to be moist in order that they may breathe through them. Earthworms also breathe through their skins. A superstition is that they have been rained down. Instead, they have come up out of the ground.

Much of the best soil has been carried away from our hilly fields by the water from rains. The streams carry this good soil down to the lower ground, forming rich lowlands. Very little soil washes from grasslands. By keeping the slopes in pasture grasses much of the time we can prevent most of the loss of soil. The roots of grasses are the best soil holders. These tiny roots are wrapped about the soil particles.

References

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 41–45.

*———, HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book II, Chicago: Scott, Foresman & Company, 1935, pp. 32–41, 117–121.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 97–103.

FABRE, JEAN HENRI: "The Secret of Everyday Things," New York: D. Appleton-Century Company, Inc., 1921, pp. 329–343.

McFEE, INEZ N.: "Little Tales of Common Things," New York: The Thomas Y. Crowell Company, 1918, pp. 3–9.

NEEDHAM, JAMES G.: "The Natural History of the Farm," Ithaca, New York: Comstock Publishing Company, 1914, pp. 281–284.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 88–91.

*REED, W. MAXWELL: "And That's Why," New York: Harcourt, Brace & Company, 1932, 55 pp.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book I, Philadelphia: J. B. Lippincott Company, 1931, pp. 58–60.

*——— and ———: "Early Journeys in Science," Book II, Philadelphia: J. B. Lippincott Company, 1931, pp. 154–157.

*THOMPSON, JEAN M.: "Water Wonders Every Child Should Know," New York: Grosset & Dunlap, 1907, pp. 205–233.

VAN CLEEF, EUGENE: "The Story of the Weather," New York: D. Appleton-Century Company, Inc., 1929, pp. 29–81.

MAKING MAPLE SUGAR

Aims

A means of enjoyment in late winter.

Some comprehension of our dependence upon plants. Awareness of the rise of sap and the consequent changes resulting from a renewed supply of energy from the sun.

Suggestions

The sap of the sugar or hard maple yields the most sugar, but the silver or soft maple and the box elder or ash-leaved maple are tapped in some parts of the country and will serve the purpose in carrying out this project. Choose a tree more than six inches in diameter, that the toll of sap may not interfere greatly with the season's growth. Tap the tree when the rise of sap is well begun.

If metal spiles are not available, a homemade one can be constructed from the stem of either elderberry or common sumac. Choose a stem a little over an inch in diameter or slightly larger than the hole to be bored in the tree, and cut off a section about twelve inches in length. About three inches from one end saw halfway through the stem. Turn the section over and do the same three inches from the other end. Split from cut to cut to form two spiles. Punch out the soft pith to leave a hollow tube at the basal end and a trough at the split end. With a brace and a seven-eighths-inch bit, bore a hole about two inches into the tree, slanting the bit slightly upward. Whittle the base of the spile to fit the hole, and drive it securely into place. Place a container in position to catch the sap.

Taste the sap, and note that it contains sugar that was stored in the roots during the winter. Consider why the roots are a good storage place. Note that buds are beginning to swell. Discuss the significance of the rise of the sap and the purpose for which the tree uses the sugar that has been stored. Be sure that all the children understand that the tree must build a new factory (leaves) before it can start the manufacturing of sugars again.

If an electric grill can be secured or some other source of heat is available, the sap may be evaporated (boiled down) in the

schoolroom; otherwise some of the pupils may be willing to do this at home. Keep a sample in the syrup stage, and make the rest into sugar. The children may decide to have a maple-sugar party at which they summarize the results of their study and enjoy the fruits of their efforts.

Talk about the different foods made by plants and about our dependence upon them. Discuss the significance of the storage of food and of the rise of sap in spring.

Contributing Learnings

The sap of maple trees and of other plants contains sugar. Maple sugar is like the sugar made by other plants with the addition of some materials from the tree which give it a different flavor.

Sugar is the commonest food in all the world and the one out of which most other foods are entirely or largely made. Much of the food we eat is starch. Starch consists of sugar combined and changed into a new form. It can be changed into fats and into many other forms.

The sugar is made in the leaves of plants out of water and gas (carbon dioxide from the air). The sun's energy runs the leaf factory, and some of the energy is stored in the sugar. When plants and animals, including people, use the sugars and other foods made from sugar, they are really getting energy that came from the sun.

During the late spring, summer, and early fall, the trees are busy making sugar. Some of the sugar is used in the growth and work of the plant. It helps to make new bark, wood, buds, flowers, and fruits. The extra sugar is carried down through the bark to the roots of the tree, where it is changed into starch and stored over winter. When the water in the ground thaws in late winter, the starch in the roots is changed back to sugar. It then passes up through the outer layers of wood in the roots, trunk, and branches to the buds. The supply of sugar is used there to make new growth. The buds, which are growing points, first swell and then begin to grow out into twigs. Along the twigs new leaves and buds are formed. Flowers and later fruits grow from some of the buds. By late spring the leaves are full size on most trees, the days are long and warm, and the sugar-making factory is going full speed.

Not only maple trees, but all green plants, make food. The leafgreen of summer is such a big factory that it furnishes food for virtually all living things. Some of the plants live only one year. It is only perennials that store great quantities of food in the roots.

The sugar is carried up the tree in the watery sap. If we wish to get sugar from plants, we collect or press out the sap and boil it to evaporate the water. When most of the water is evaporated, we have syrup. If we continue to evaporate the water, the sugar is left as crystals. We tap maple trees in the late winter when the stored food is rising. If we tap young trees, or if we tap older trees in too many places, we rob them of such a large part of their sugar that they are weakened. The growth of twigs and leaves is lessened, and the trees may even die.

References

*CHAMBERLAIN, JAMES F.: "How We Are Fed," New York: The Macmillan Company, 1923, pp. 88–92.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 736–744.

*CURTIS, MARY I.: "Stories in Trees," New York: Lyons and Carnahan, 1925, pp. 172–178.

*FISHER, CLYDE, and MARION L. LANGHAM: "Nature Science," Book II: "Ways of the Wild Folk," New York: Laurel Book Company, 1935, pp. 172–188.

NEEDHAM, JAMES G.: "The Natural History of the Farm," Ithaca, New York: Comstock Publishing Company, 1914, pp. 168–174.

*PATCH, EDITH M., and HARRISON E. HOWE: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 158–168.

*ROCHELEAU, W. F.: "Products of the Soil," Chicago: A. Flanagan Company, 1928, pp. 68–76.

MAKING WHISTLES

Aims

An interesting leisure-time play activity. Interest in interpreting the growth of trees and in musical sounds.

Some contribution to the concept that higher plants are coordinations of specialized units of life.

Suggestions

Almost any kind of branch will do, but willows and box elder are among the most suitable. They are readily obtained, as both are abundant and of little value.

Cut through a branch the size of your finger or larger, making a slanting cut. This end will be the mouthpiece of the whistle. Cut a notch through the bark and a short way into the wood on the upper side just beyond where the lip will reach. About three inches farther down the twig, cut through the bark completely around the twig. Allow another inch or more for holding the whistle, and cut through the branch. Pound the bark gently on all sides back to where the branch was ringed until it can be removed with a slight twist. Cut a very little of the wood from the upper side of the mouthpiece and remove most of the wood from the notch back almost to the end of the exposed portion. Replace the bark, and the whistle is complete. Practice until the children can make good whistles and have achieved satisfaction. Then begin to utilize this point of departure for furthering understanding.

Find the age of the wood used for making whistles by counting the annual rings and also by counting the terminal-bud scars. Note that the pith is just as large in one-year-old twigs as in older ones. Decide which is the oldest ring of wood or, in other words, whether the tree grows at the center or at the outside of the wood. Decide which is probably the oldest bark on a tree. Let the children explain why it is easier to make whistles in the spring.

Work out together the story of the growth of the twig and the work done by the bark, cambium, wood, and pith. Children can now understand the principle in grafting plants. It is not advisable to attempt to distinguish and name all of the regions of the stem.

Note the variations in pitch among the whistles. Try making long whistles, short ones, thin ones, and thick ones to discover what determines the pitch. Note also variations in tone character, and try to account for them. Discover what musical instruments work on the same general principle as the whistle. Consider the uses made of whistles.

Contributing Learnings

Between the bark and the wood is a layer of cells (cambium) which divide to form new cells. Some of these new cells develop into bark; still more of them go to form the wood.

The new cells are formed throughout the spring and much of the summer. The growth of wood during one year is known as an annual ring.

When first formed, the new cells are small and fragile. When we pound the bark in making the whistle, we crush the delicate young cells, causing the bark to separate from the wood. As most of the new cells are formed early in spring, it is easier to make whistles at this time of year. In the fall most of these cells would have become heavy walled and hard to crush.

In grafting a twig or bud on another plant it is necessary to have the growing layers of the two in contact if they are to grow together.

The pith does not grow after it is once formed and is no larger in an old tree than in a one-year-old twig. It served as a place to store food in the young twig but is useless in the older branches and trunk. When we make popguns, we choose plants with large pith which can easily be punched out to leave a hollow gun barrel.

The bark carries the food made by the leaves down to the trunk and root cells. It also protects the growing region from drying out and from infection. In young green stems food is made in the bark as well as in the leaves.

Water and minerals are carried up to the leaves through the wood. The wood also stiffens the plant and enables it to support the great food-making leaf surface.

When we blow into a whistle, we set the column of air vibrating to produce the sound. Fife, flute, organ pipes, and horns work on this principle. In the reed instruments, the column of air is set in motion by a vibrating reed or tongue.

The longer the vibrating air column in the whistle the slower the rate of vibration and the lower the pitch. The quality of the tone

varies with the material used for the whistle and the way in which it is made.

Whistles are used as signals for beginning and ceasing work, for danger signals on boats and trains, for musical instruments, by referees and play directors, by postmen and policemen, by persons in need of help, and for many other purposes.

References

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 154–159.

SETON, ERNEST THOMPSON: "The Book of Woodcraft," Garden City, New York: Garden City Publishing Company, 1921, p. 450.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 316–320.

KEEPING A SPRING DIARY OF A TREE

Aims

Intimate association with trees which makes for appreciation. Interest in observation and discovery.

Some elementary understanding of the life history of a plant and of interdependence. Awareness of seasonal changes.

Suggestions

This is a continuation of the fall and winter diary, although tne project can be begun at any time.

Visit the tree while it is still in winter condition. Note that there are buds ready to begin spring growth. Open a few buds to see whether they are still alive. Observe whether the buds have increased in size during the late winter.

As growth progresses, raise such problems as the following, and commend each observation that leads to their solution. Which develops earlier, the tree or the small plants that grow beneath it? Can you think of a possible explanation for this? Which buds develop first on a twig? Can you think of a possible use for the buds that do not develop? What becomes of the scales that protected the buds? What grows first from the bud? Where do the new leaves develop? Do all of the buds grow into leafy twigs? Do flowers or leaves appear first? How can you tell where the new growth started each year? How rapidly do the new twigs grow? (Measure a twig at frequent intervals.) Describe the flowers. When is the pollen shed? Is it sticky enough to cling to bees and other insects, or is it dry and easily blown about by the wind? Do insects visit the flowers in large numbers? When do the fruits appear? What forms them? Describe the fruits. What becomes of them? How are they scattered? How long does it take the leaves to grow?

Visit the tree frequently during the spring, and keep a diary of the observations. Preserve flowers, fruits, and leaves of the tree for a permanent mount.

Keep a record of the animals that visit the tree or make homes in it. Discuss their various relationships with it.

Talk about what the tree will be doing during the summer while we are away on our vacations.

Contributing Learnings

Buds are growing points. The buds that will make this year's growth were formed last spring. Most of the buds have remained alive during the cold winter. Some of them are killed during unfavorable seasons. These can be recognized by their black centers (the dead growing points darken).

During the late winter the buds near the tips of the twigs often enlarge. When the sap containing the stored food comes up from the roots, many growing points (buds) begin to grow out into new twigs. The bud scales, which have protected the growing points, now drop, leaving scars which mark where the bud rested over winter. As the twigs grow out, new buds are formed along them. Above each new bud a tiny leaf appears and grows to full size in a few days. The buds will remain on the twigs until the following spring. The leaves will make food during the summer and store it in the roots for use when growth starts again.

The flowers appear before the leaves on many trees, especially those which produce dry, wind-blown pollen. The insects carry the pollen of trees that offer nectar. The pollen is necessary if the flower is to develop into a fruit.

Fruits contain seeds to start new trees. They are carried to their new homes in various ways.

Animals are interested in our tree. They use it for food, shade, homes, and protection from their enemies. They are often useful to trees. They carry pollen and seeds about. Birds destroy many of the insect enemies of trees. Some birds eat buds and fruits.

The small plants growing beneath the trees usually flower and fruit early, before the dense shade of the trees shuts off the sunlight from them.

References

*Athey, Lillian Cox: "Along Nature's Trails," New York: American Book Company, 1936, pp. 203–234.

Hawksworth, Hallam: "A Year in the Wonderland of Trees," New York: Charles Scribner's Sons, 1926, pp. 112–176.

Mann, Paul B., and George T. Hastings: "Out of Doors," New York: Henry Holt & Company, 1932, pp. 193–216.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1928, pp. 31–35, 45–48, 85–87.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 54–59, 197–202.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 194–200.

DISCOVERING WHICH TREES WAKEN FIRST

Aims

Interest in the spring season with its new growth and developments. Joy in discovering.

Some elementary experience contributing to concepts of reproduction, adaptation, and interdependence.

Suggestions

Before any new growth appears, test for the rise of sap by cutting a tiny twig and noting whether a watery solution exudes.

Look for swollen buds before any flowers or leaves appear. Open a few of the largest buds, and try to discover whether they will develop into flowering twigs or leafy ones.

During March and early April keep close watch for new growth on such trees as maples (including box elder), poplars of all kinds, willows, elms, ashes, birches, cherries, plums, hackberry, buckeye, and ironwood. Observe the elongation of the growing points (buds) and the appearance of flowers or leaves. Mark a few developing buds of some rapid-growing tree (willow is good) by tying colored strings around the branches, and measure the growth from day to day with a ruler.

Compare the flowers of these early-blooming trees. Look for the pollen. Locate the pistils by their swollen bases (ovaries) which will become the fruits. Discover whether both stamens and pistils are borne on the same tree. Consider what this has to do with producing seeds.

Note whether these early flowers have strong odors which would attract insects. Discover whether many insects visit them. Find whether the ripe pollen will stick to your pencil readily. Discover whether the pollen sacs are hung from long stamens where the wind could easily scatter the pollen. Blow the ripe stamens about with the breath to discover whether the pollen is easily scattered by the wind.

Keep a record of the order of development of a few of the common trees. Be sure to include some late-blooming trees such as basswoods, locusts, and catalpas. Compare the flowers of these trees with the earlier types. Note whether the flowers

appear before the leaves do on trees with late-appearing, showy, odorous flowers. Watch the development of the fruits.

From your records, determine how long a time it takes an elm tree to mature its fruits and to develop its leaves in readiness for food making and storage.

Press and mount the flowering and fruiting twigs of the trees for the schoolroom, dating each specimen.

Contributing Learnings

Buds are the growing points. They remain on the trees over winter.

The extra food made during the summer is stored in the roots, a small amount remaining in the twigs. Early in the spring, when the sun begins to warm the soil and the plant, the sap begins to rise. It carries the stored food from the roots up to the buds.

Some of the buds (usually the ones near the ends of the twigs) now being supplied with food begin to grow. Each bud develops into a twig. On some trees these new twigs bear only flowers; on others they bear only leaves; and on still others they bear both flowers and leaves. All leaves and flowers appear on the new twigs, never on the old branches.

The first of the common trees to bloom are usually the red maple, the silver maple, and some willows. They are followed in April by other maples and willows, the elms, poplars, birches, ironwood, ash, hackberry, and butternut. In the south the trees bloom earlier, and there are many more kinds.

Most of the early-blooming trees have flowers suited to wind pollination. The flowers appear before the leaves which would interfere with the action of the wind in scattering the pollen. The stamens are usually exposed and easily shaken about by the wind. The pollen is dry and easily blown about. It does not stick to objects well. The flowers are not very showy. There is usually little odor, and few insects visit the flowers. There are, however, some exceptions among the early-blooming trees.

The pollen is in sacs borne on stalks. The stalk and sac are together called a stamen. Stamens do not grow into fruits, but the pollen is necessary if the swollen base of the pistil is to develop into a fruit. The top of the pistil stalk is sticky and catches the pollen. If the right pollen is carried to the pistil by wind or insects, the base of the pistil (ovary) usually grows into a fruit containing seeds which are capable of starting next year's plants.

Willows, poplars, and the box elder do not bear the stamens and pistils on the same tree. This means that some trees bear pollen and are, therefore, necessary but never bear fruits. Other trees with pistillate flowers bear fruits and must receive the pollen from the first type. This often explains why even a pistil-bearing tree planted far from others of its kind does not fruit.

Most of the late-blooming trees have showy, odorous flowers with sticky pollen, appearing with or after the leaves. Many insects (mostly bees and flies) fly from flower to flower gathering nectar and pollen. Some of the pollen clings to the insects and is carried to the sticky tops of the pistils.

The trees flower and come into full leaf in a few weeks. Some trees, such as the elms, develop fruits and scatter them before the leaves are grown. On some trees the fruits grow throughout the season. In addition to producing fruits with the food they make, the trees store some of it in the roots. This will be used in development the following spring.

References

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 89–94.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 133–139.

EMERSON, ARTHUR I., and CLARENCE M. WEED: "Our Trees—How to Know Them," Philadelphia: J. B. Lippincott Company, 1908, 295 pp.

*GORDON, EVA. L., and JENNIE HALL: "Nature Stories for Children—A Spring Book," New York: Mentzer, Bush & Company, 1927, pp. 38–46.

HAWKSWORTH, HALLAM: "A Year in the Wonderland of Trees," New York: Charles Scribner's Sons, 1926, pp. 133–170.

OTIS, CHARLES HERBERT: "Michigan Trees," Ann Arbor: University of Michigan, 1915, 247 pp.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 194–199.

ROGERS, JULIA ELLEN: "Trees That Every Child Should Know," New York: Grosset & Dunlap, 1909, pp. 143–180.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 316–323.

RUNNING A PLANT-GROWING RACE

Aims

Interest in growing plants. Joy in discovery.

A better understanding of the difficulty in controlling the conditions of an experiment. Some understanding of the superiority of the experimental method over that of uncontrolled experience in finding out what we wish to know.

Contribution to the concept that the realization of the inherent possibilities of each living thing is dependent upon a complex of environmental factors.

Ability to grow plants more effectively.

Suggestions

Secure seeds of some easily grown plants such as bean, barley, sunflower, or radish. Let the pupils divide the seeds equally, and leave them free to try any methods they wish. Set a day for judging results.

They may choose their soil, mixing sand, clay, loam, leaf mold, or peat in any proportions. The seeds may be planted at any depth. Watering can be done at any time, in any quantities, and in any manner they choose. The containers may be kept in any locations that the pupils deem best suited for rapid growth. Any kinds or amounts of fertilizers may be used, including manure. It is well to have the same kind of container for each child. Tin cans with the edges rolled smooth make good containers.

Keeping careful records of the treatment given the plants is part of the race. The winner must be able to show exactly how the plants were grown. This adds interest to the activity and makes it possible for the children to make comparisons and to attempt to draw tentative conclusions.

Let the pupils pick out a number of the best pots of plants and an equal number of the poorest. By examining the records kept by the winners and losers, let them try to discover what conditions the plants need.

It will soon be evident that there were too many variable factors to make it possible to discover the causes for success and failure. Let groups of the pupils carry out other races in which

only one condition will be varied by each group. Examine the results of the second race, and prepare simple statements of the findings. Discuss the chances that other conditions may have influenced the results and whether the conclusions necessarily apply to growing other kinds of plants.

Contributing Learnings

Sandy soils give quick growth. They warm quickly and allow air to reach the roots. They are not rich in the materials needed by plants. They do not hold a large amount of water, and they dry out quickly.

Clay soils hold water well and are richer than sandy soils, but they bake very hard when they become dry. They do not let air reach the roots when they are very wet.

Peat and leaf mold hold water well, allow air to reach the roots of plants, and do not pack or bake. They are not fully decayed and are not rich.

By mixing sand, clay loam, and leaf mold we have an excellent soil for growing plants.

Some fertilizers hasten the growth (especially nitrogen), but too much commercial fertilizer and fresh manure keep plants from taking up water. Well-rotted manure is a good fertilizer.

Plants need water. Sugar is made partly of water. Materials are carried through the plant in water. Water keeps the leaves tight and fresh so that they remain spread out to catch sunlight. When plants do not have enough water, the leaves wilt, and very little food making or growth can take place. If water is withheld very long, some of the leaves fall, and finally the plant dies.

It is better to water plants heavily and less often than to give them light sprinklings frequently. Light watering wets only the top of the soil, and the roots grow close to the surface where there is water. Shallow-rooted plants dry out badly if not watered for a short time. In sooty cities it is well to wash the leaves of plants occasionally.

The air as well as the soil should be kept moist. The air is so dry in our homes and schools that plants do not do well even if we water the soil regularly. Porous flowerpots which allow the water to escape through the sides are not so good as glazed ones.

Plants need light. The energy of sunlight runs the food-making factory in the leaves. Strong light slows growth but makes plants tough and strong. During cloudy weather, plants often

grow tall weak shoots. This also happens in our homes with some plants unless they are placed close to sunny windows.

Some plants are sun plants. They do best in the open sun. Others are shade plants. Plants that need long hours of sun are called long-day plants. They will not flower freely during the short days of spring and fall or in the house where the sun falls on them only a few hours each day. Spring flowers and most of the house plants are short-day plants.

Plants make a rapid growth only when the soil and air are fairly warm.

It is only by keeping all conditions the same in an experiment, except the one we wish to study, that we can find out what we wish to know.

Each kind of plant and animal has its needs. We must study these needs if we wish to get the best possible growth. The problem is a difficult one.

References

*Beauchamp, Wilbur L., Harriet M. Fogg, Gertrude Crampton, and William S. Gray: "Science Stories," Book III, Chicago: Scott, Foresman & Company, 1936, pp. 48–75.

**Cornell Rural School Leaflet*, Vol. 20, No. 3: House Plants, Ithaca, New York: Cornell University, January, 1927.

Davis, Kary Cadmus: "School and Home Gardening," Philadelphia: J. B. Lippincott Company, 1918, pp. 293–334.

*Greve, Anna M.: "Soil: Its Sources and Uses," Columbus: American Education Press, 1935, 24 pp.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book IV: "Through Four Seasons," New York: The Macmillan Company, 1933, pp. 209–224.

*Persing, Ellis C., and C. Louis Thiele: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 210–251.

STARTING TREES FROM SEEDS

Aims

Satisfaction that comes through growing things.

Knowledge, experience, and appreciation which make for conservation and restoration.

Elementary experience contributing to the concept of dependence of living things on the factors of their environment.

Suggestions

Tree seeds should be planted in beds. Otherwise, the seed is virtually wasted. The school nursery may be started either in fall or in spring. In either case it must be continued the following season. Some tree seeds succeed best if planted in fall; others, in spring. Since interest in planting is at its height early in spring, it may be well to start then. Other seeds can then be added in the fall.

The first step is to select a location. The principal considerations are moisture, soil, and shade. If no location suitable in any or all of these respects can be found, choose any convenient spot, and remedy the conditions. A low area where water does not stand will practically eliminate any need of watering the seedlings. If the area is shaded from the south and west sun by a tree or building, no shade need be constructed. If the seedbed is to be near a tree, remove competition of the tree roots by ditching to a depth of eighteen inches on that side of the bed. A sandy loam soil is ideal. Unsuitable soil conditions can be remedied by adding sand and leaf mold to heavy clay or rich humus to a dry sandy soil.

The area need not be large. In a plot ten feet long and half as wide, thousands of trees can be started and yet leave room for weeding operations. A much smaller nursery will do.

It is very important to fence the nursery against accidental trampling by people and attack by rodents. Even birds should be excluded until the plants are well started. The usual method of enclosing evergreen seedbeds provides protection and furnishes the necessary shade. Short stakes made of two by four-inch pieces are driven in the ground at the corners of the bed, leaving

only about ten inches of the stake exposed. A top frame is constructed by nailing laths at intervals across two by two-inch runners. The usual procedure is to leave spaces between laths no larger than the width of a lath. The corner stakes are then notched to receive the top frame, which can thus be removed while the beds are being weeded. Coarse galvanized screen or netting is then tacked around the sides. The plants receive alternate shade and sun and are protected against intruders. For the rapid-growing seedlings of the broad-leaved trees, shade is not so important. Accordingly, a higher enclosing fence may be used, the slatted protection being omitted, although it is helpful during the first season.

Spade the soil, and work it down fine. Rake it level, and pack it a little by laying a board on the bed and tramping on it.

Evergreen seeds may be planted at any time during the spring. It is well to plant as soon as the ground is warm in order that the plants may be well started before school closes.

Fall planting of evergreen seeds is also successful in most localities. Seeds of most of the broad-leaved trees should be planted soon after they ripen in the fall. See suggestions for the project "Saving Seeds for Planting."

Collect seeds from trees growing in the community. A few seedsmen sell tree seeds (see the references). While the prices of some seeds may seem high, the number of seeds per pound should be taken into consideration in purchasing. A pound may contain as many as 75,000 spruce seeds.

In planting the smaller seeds such as those of evergreens, scatter them very thickly and as evenly as possible on the surface of the bed. Cover the seeds with a quarter inch of soil obtained at a depth of a foot or more below the surface. This soil is preferable for the purpose, as it contains fewer fungi which might attack the seedlings and fewer weed seeds. Water the soil if it is dry, being careful not to expose the seeds. Burlap sacks spread over the ground until the plants come up will help to prevent it from drying out. Place the slatted cover over the bed, and watch for the plants to appear in a week or two. If the ground becomes very dry or bakes, it may be necessary to water again. Avoid overwatering, as that favors the damping-off fungi.

Evergreen seedlings can remain in the seedbed for two years with little or no care, except weeding and occasional watering in case of drought. Most other tree seedlings can be transplanted

at the end of a year. The seedlings may be planted on the school ground or given to the children to plant around their homes. They can also be potted and sold to pay the expense of this and other projects. Ask the State Bureau of Plant Inspection to inspect them for plant diseases and insect pests. The inspectors will gladly stop at the school on one of their regular trips in your territory.

In transplanting evergreens, the roots must be kept moist. Before attempting to transplant any evergreens from the seed-bed be sure to read carefully the suggestions under the project "Planting a Tree."

Contributing Learnings

Seeds are baby plants provided with food and protected by coats. Each tree seed, if given the conditions it needs, will grow into a tree somewhat like the parent.

Each tree produces many seeds. If even one seed from each tree grew each year, there would be trees everywhere about us. But a great many of the seeds are eaten by animals. Many others fall where they have no chance to get started. Only a small percentage of the seedlings survive.

By planting the seeds carefully in suitable soil and protecting them, we can start more trees in a tiny plot of ground than might otherwise grow in a season on many acres of ground.

Seedlings need moisture, light, warmth, and suitable soil. They usually grow in the woods where the sun does not shine continuously on any one spot very long at a time. By experimenting, it has been found that a slatted shade providing this type of lighting is satisfactory.

We need to plant many trees, as our forest timber is almost gone. We could also make our homes and roadsides more beautiful with trees. If all people understood how to start trees and knew how simple it is, they would grow trees as we now grow other crops.

References

Blakeslee, Albert Francis and Chester Deacon Jarvis: "Trees in Winter," New York: The Macmillan Company, 1926, pp. 45–55.

**Cornell Rural School Leaflet*, Vol. 20, No. 2: Babes of the Woods, Ithaca, New York: Cornell University, November, 1926.

Hodge, Clifton F.: "Nature Study and Life," Boston: Ginn and Company. 1902, pp. 365–398.

MADDOX, RUFUS, and ALMON E. PARKINS: "Our Trees and How They Serve Us," New York: Charles Scribner's Sons, 1925, pp. 157–164.

U. S. Department of Agriculture, *Farmers' Bulletin:* Growing and Planting Hardwood Seedlings on the Farm, No. 1123; Growing and Planting Coniferous Trees on the Farm, No. 1453.

A few sources from which tree seeds may be obtained are:

Conyers B. Fleu, Jr., Ross and Montana Streets, Germantown, Philadelphia, Pa.

Evergreen Seed Company, Evergreen, Colorado.

Herbst Brothers, Inc., 92 Warren Street, New York.

Local nurserymen and seed houses.

PLANTING A TREE

Aims

Interest in the tree-planting and -conservation program through participation. Experience contributing to attitudes of social service, cooperation, and civic responsibility.

Satisfaction in growing things.

Knowledge and standards for the planting and care of trees.

Suggestions

The project should be begun a week or two before Arbor Day. Arouse interest in tree planting. Read poems and sing songs about trees. When interest has reached a high pitch, plan to plant a tree on the school ground.

The first problem is to choose the planting site. This brings up consideration of the purposes for which trees are planted on grounds. If the building needs shade from the noon or afternoon sun, select the best location to provide it. If the front of the building stands out in displeasing ugliness, plan the location of trees to frame or soften the view of the building. If these matters have been taken care of, plan to plant a tree along the margin of the grounds to attract birds. A specimen tree may be planted for beauty where it will not interfere with play.

The next problem is to select the kind of tree to plant. Having decided the purpose for which the tree is needed, compare the advantages and disadvantages of some common trees. Make trips to homes or streets where these trees are growing. Look up the height, the type of fruits, and other characteristics in tree books.

It is best to secure the tree from the nearest nursery, unless some of the parents have a tree to contribute. In several states the forestry or conservation department will furnish the trees for planting on public grounds. In cities the park commission or other city officials are usually glad to cooperate in this way. Otherwise, ask the parent-teacher organization to supply the tree if school funds are not available. Smaller trees, four to six feet in height, are easier to plant, grow better, and cost very little.

Let the children dig a large hole (four feet in diameter and two feet deep is sufficient for most young trees), working in shifts. If the task proves heavy, spread it over more than one day. If the soil is poor, get some one to bring in a few wheelbarrow loads of black dirt to place in the bottom of the hole and to pack next to the roots.

When Arbor Day comes, plant the tree with appropriate exercises. But, above all, see that it is properly planted. Cut away any diseased or broken roots to prevent disease and decay. Set the tree in position, and spread the roots. Shovel in a few inches of black dirt, meanwhile slightly raising and lowering the tree to let the dirt fill in under the roots. Tramp the dirt firmly. Fill the hole with water, and proceed with the exercise while the water sinks away into the ground. Repeat until the ground is thoroughly soaked. Nearly fill the hole with earth now, and tramp it down. Pile some of the loose soil in the form of a raised crown about the hole to hold water. Fill in water to the top of the crown. When the water sinks away, drag a little loose dirt over the wet earth, but leave the crown to collect water when rains come (remove the crown before freezing weather in the fall to prevent injury by the ice which would form about the tree).

If the tree has not been pruned, cut away most of the top, shortening each main branch at least one-half.

Drive three stakes, or set posts about the tree to protect it. Wrap a short piece of inner tube of an automobile tire or other protecting band about the trunk to prevent injury, and wire or tie the tree to the three stakes. This will prevent the wind from blowing it about and breaking the young roots before they become well established.

Water the tree once a week until school closes (unless heavy rains occur), filling the depression about it with water two or three times. Do not water lightly each day, but thoroughly soak the ground once a week.

Planting a tree is an important educational activity and it ought to be done in such a way as to teach a vital lesson. It is much better to err in being unnecessarily thorough than to do the job carelessly.

Discuss the need for tree planting. Learn about the reforestation program. Find places in the community where trees ought to be planted.

Consider all of the ways in which trees are important to us.

Contributing Learnings

Trees mean much to us. They furnish shade, windbreaks, beauty, food, homes, furniture, fuel, rayon clothing, boats, wagons, and many useful articles.

Fires, lumbering, and farming activities have destroyed most of our trees. Few have been planted to take their places. With the disappearance of trees, many other plants and the animals that depend upon trees for shelter and food can no longer exist.

Most schools and many homes are bleak, barren, wind-swept, and sun-baked places which could be made beautiful with trees. Trees would also bring birds and other animals about our homes.

Our government is beginning to plant more trees, but more are destroyed each year by fire than are planted. The government is asking all of us to plant trees. The trees that we plant at school may not grow big enough to be of much help to us before we graduate and go on to another school, but they will be enjoyed by other children as well as by the birds, squirrels, and other living things. In turn, we shall enjoy the trees planted by other people in other schools, in parks, boulevards, homes, and woods.

A tree is a living thing and must be moved with care, or it will die. The root system of a tree is often as large as the top. The roots take up from the ground water and other materials which the tree needs. In digging a tree we get only a small part of the root system. A newly transplanted tree thus has a small and crippled root system and cannot take up enough water to keep the top from drying out. Therefore, we cut away (prune) most of the top, leaving only what we think the roots can supply. The tree will soon grow a larger root system and a new top.

We must keep plenty of water in the ground and thus give the crippled root system as much help as possible until new roots are formed.

The dirt must be packed tight about the roots. Otherwise, they cannot get the water and will dry out and die.

The roots support the tree and keep it from blowing over. When the wind bends the tree, the roots are stretched and may even be broken. When our tree has built a strong new root system, it will be able to withstand the push of the wind. Until that time it can be supported in place and protected.

Planting a tree is an important task, for the tree should still bring joy to people when we are old. It requires hard work and

care. But it is also a great joy, for we shall watch the new growth and life on our school ground.

References

BAILEY, L. H.: "Manual of Gardening," New York: The Macmillan Company, 1916, pp. 126–135.

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 89–97.

BLAKESLEE, ALBERT FRANCIS, and CHESTER DEACON JARVIS: "Trees in Winter," New York: The Macmillan Company, 1926, pp. 102–113.

Cornell Rural School Leaflet, Vol. 15, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1921.

Cornell Rural School Leaflet, Vol. 23, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1929.

PACK, CHARLES LATHROP: "Trees as Good Citizens," Philadelphia: J. B. Lippincott Company, 1922, pp. 76–86.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 210–214.

*——— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 235–239.

U. S. Department of Agriculture, *Farmers' Bulletin:* Growing and Planting Hardwood Seedlings on the Farm, No. 1123; Growing and Planting Coniferous Trees on the Farm, No. 1453; Transplanting Trees and Shrubs, No. 1591.

STARTING PLANTS FOR OUR HOME GARDENS

Aims

Absorbing interest in growing plants.

Contribution to concepts of reproduction and of the dependence of living things upon a complex environment for realization of their inherent possibilities.

Useful knowledge of methods of propagation.

Suggestions

Discuss gardening with the children until they are eager to undertake it. Have seed catalogues in the room with flower and vegetable pictures in color.

Make plans for summer home gardens. Find out how many children can have a small garden space at home into which to transplant the plants to be started at school. Even a window box will do. It may be advisable to send a note to all parents explaining the plan and asking cooperation. Call attention to the school fair to be held in the fall.

Each child should clear the space for his home garden, measure it, and drive stakes to mark the corners, thus insuring holding the area until his plants are ready to bring home. Lettuce and radishes may be planted now in alternate rows, and the radishes will be harvested by the time that the space is needed for the plants grown at school.

Each pupil should draw a plot of his garden and plan with the teacher the flowers and vegetables that he intends to plant.

Procure wooden boxes, or "flats," as they are called, about four inches deep. In some, place light soil for planting seeds and, in others, clean sand for starting cuttings. Fill the flats to within one inch of the top. If they are entirely filled, much muddy water will be splashed about later in watering the plants.

Mark the ground in the seed boxes with parallel lines both ways to insure even spacing of plants. Two-inch intervals for seedboxes and three-inch intervals for cuttings are suitable. The seeds may be drilled or broadcast if preferred.

In the boxes of soil, plant seeds of zinnia, aster, marigold, phlox, verbena, salvia, or any of the hardy flowers that transplant well. Tomato, cabbage, cauliflower, and sweet pepper are probably

the most suitable vegetables. Plant several seeds at each intersection of the lines. Cover lightly, and pack the soil a little. Later thin the plants to one or two. Sweet-potato plants may be started by burying sound sweet potatoes in a box of soil. The sweet potatoes should be covered with about two inches of soil in which the shoots will make their root systems. When the plants become well rooted, they are ready to be pulled and transplanted. More plants will then develop. A simpler but inferior method of obtaining plants consists in placing the sweet potatoes in the necks of fruit jars or milk bottles filled with water.

Make cuttings about three inches long from mature stock plants of geranium, vinca, ivy, coleus, begonia, or impatiens plant. Cuttings from young watery shoots often develop soil rots. Cuttings of most of the harder, woodier plants are slower to root. If the cutting has a large leaf surface, pinch off some leaves. Allow the cut ends of the stems to dry before setting them in the sand as a prevention against decay. Set one cutting at each string intersection, and water heavily. Do not water cuttings again for some time. Overwatering favors soil rots.

When the seedlings are large enough to transplant, the cuttings well rooted, and danger of frosts over, the plants should be transplanted into the home gardens. Begin to harden the plants to the outdoors by placing them on the outer window sill for a few days before transplanting. Water them heavily a few hours before taking them up to transplant. Dig up some dirt with each plant, disturbing the roots as little as possible. Wrap the plants, with a small ball of wet earth about the roots of each, in heavy newspapers in order that they may reach their outdoor homes in good condition. Urge that the ground be prepared beforehand and that the plants be set and watered freely immediately after being taken home.

Be sure that parents understand the importance of the child's own activity so that they will only advise and not assume care of the plants during the summer.

Make plans for entering the products or photographs of the child and his garden in the school fair next fall.

Contributing Learnings

Plants require warm conditions in order to make rapid growth. By starting our plants indoors while the garden soil is still cold, we get a crop much earlier.

Plants can be started from seeds which contain baby plants or from portions of the old plants.

When crowded too close together, plants do not have the necessary light and moisture for good growth. Instead of being sturdy, they become weak and slender.

Plants grown in the warm shady schoolroom are not hardy if suddenly transplanted out of doors where they must endure hot sunny days and cold nights. For this reason we harden them by setting the flats out of doors for a time before transplanting the plants. Infancy is a difficult time for plants as well as for animals.

Plants need water, light, air, and good soil, as well as heat. The roots must not be allowed to dry out, even during transplanting. On the other hand if water stands on our plants, they become sick because the roots cannot get air.

Spring is the season when most new life appears. Then we must do our planting if we are to be able to live until the next growing season.

References

BAILEY, L. H.: "Gardeners' Handbook," New York: The Macmillan Company, 1934, 292 pp.

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Readers," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 97–105.

**Cornell Rural School Leaflet*, Vol. 29, No. 3: House Plants, Ithaca, New York: Cornell University, January, 1927.

*CRAIG, GERALD S., and AGNES BURKE: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1932, pp. 165–179.

DAVIS, KARY CADMUS: "School and Home Gardening," Philadelphia: J. B. Lippincott Company, 1918, 339 pp.

DOWNING, ELIOTT ROWLAND: "Our Living World," Chicago: The University of Chicago Press, 1924, pp. 410–447.

MEIER, W. H. D.: "School and Home Gardens," Boston: Ginn and Company, 1913, 307 pp.

PALMER, E. L.: "Field Book of Nature Study," Ithaca, New York: The Comstock Company, 1928, pp. 72–83.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades." Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 18–21.

*——— and ———: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 184–196.

——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 215–220.

*—— and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 219–227.

*—— and LOUIS C. THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 224–251.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 260–274.

——: "Teaching of Science in the Elementary School," Boston: Houghton Mifflin Company, 1918, pp. 23–34.

U. S. Department of Agriculture, *Farmers' Bulletin:* Growing Annual Flowering Plants, No. 1171.

RUNNING AN INSECT HATCHERY

Aims

Absorbing interest in insect life. Development of an avenue of enjoyment and education for leisure which is ordinarily closed by a feeling of repugnance for crawling things.

Experience contributing to better understanding and attitudes concerning reproduction and metamorphosis.

Suggestions

If larvae and pupae have been collected in the fall, the children will be familiar with part of the insect life story. It is even more thrilling to rear insects from eggs, and there are many additional values in having an insect hatchery.

If the other activities suggested for fall have been carried out, there is likely to be a supply of pupae on hand. If not, they can be secured from the biological supply houses for a small outlay.

It is important to have collected or to purchase enough pupae of some species that you will be almost certain to have both male and female adults. It is much better to order a number of pupae of one species than one or two of each of several kinds. Some of the larger species of moths such as Cecropia or Polyphemus and the black swallow-tailed butterfly are, perhaps, the most satisfactory.

The hatchery and brooder is very easily made. Vivariums and aquariums are the most suitable containers, but large glass jars or wood boxes are satisfactory. Gallon-size fruit jars are about the least expensive satisfactory glass containers for this and many other purposes and should be a part of the school equipment. Smear some sticky material about the upper inner edge of the container, or glue a narrow strip of fly tanglefoot paper in this position with sticky side exposed to keep the larvae from crawling out. Keep about two inches of moist (not wet) soil in the bottom. This will help to moisten the air and also provide a pupating place for any larvae that transform in the soil, as do the hawk moths, for example.

The collected or purchased pupae (probably cocoons) can be kept on the soil in the container until the adults emerge, no cover for the hatchery being needed until that time. When the adults

emerge, cover the hatchery with cheesecloth or glass until the eggs are laid, after which it can be left partly open. Note whether you have at least one adult male. If not, the eggs will not be fertile and will fail to hatch.

Some insects will attach their eggs to the sides of the hatchery, to sticks, or to any other convenient objects. Others can be induced to lay their eggs only on the plants on which the larvae feed. For this reason, and to furnish food for the larvae when they hatch, it is well to keep shoots of the food plant in the hatchery. To keep the shoots fresh, stand them in bottles of water set in the soil. Plug the mouths of the bottles with cotton or cloth to prevent any of the larvae from drowning. A cover on the hatchery at this time will help to keep the food fresh. If the eggs are not laid on the food plant, transfer the larvae gently to it when they hatch. Change the plants whenever they lose their freshness, and transfer the larvae the first few times. This may need to be done daily.

The chief problem in carrying on this activity lies in regulating the time of egg laying. Out-of-doors the moths and butterflies emerge too late to make it possible to rear the larvae before the close of school. When the pupae are kept in a warm room, the adults sometimes emerge as early as Christmas time, when it is difficult to provide food for the larvae. The difficulty can be overcome by regulating the time of emergence and planning to have suitable food on hand.

The time of emergence can be fairly well regulated by keeping the pupae in a cool place (an unheated outer corridor or building, for example) until about March. If placed in the hatchery in the warm schoolroom about this time, they will usually emerge and lay their eggs in April.

Carrot and celery tops are always available from the grocery as food for the black swallow-tailed larvae. Tree twigs can be induced to leaf out long before such food is available for the larvae out-of-doors, if kept in vases of water in the schoolroom. (See procedure for the activity "Grow a Garden from Tree Twigs.") Willow, apple, or hawthorne will suffice for Cecropia larvae. Oak is relished by Polyphemus larvae. In this way, suitable foods can be grown indoors for most of the insects that are likely to be reared.

Examine the eggs with a lens and watch the hatching process.

Observe the habits of the larvae. Watch the molting process,

and note the changes in each successive instar. When the larvae begin to pupate, spend entire periods watching the process. Write or tell the life story of the insect.

Some teachers like to preserve the life history in a Riker mount. Mount a specimen of the food plant, the adult male and female, a specimen of each larval instar, and a cocoon opened to show the pupa case in a Riker mount. The larvae must either be inflated or preserved in vials of formalin preservative. Use about a 5 per cent solution.

Contributing Learnings

It is necessary to have both male and female insects to produce young. The females produce the eggs. The males produce the sperms without which the eggs will not hatch.

Insect eggs are more varied in shape than bird eggs. They are usually surrounded by a shell. Through a hand lens the shells of the eggs of many insects appear beautifully sculptured. Most insects lay many eggs where the young may find suitable food. The eggs of many species hatch in a very few days.

The larvae are very tiny when they hatch from the eggs. They secrete a liquid which hardens to form a covering over their bodies. Most people call larvae "worms," but they are quite different. We can tell them apart by the fact that larvae usually have six legs as their parents do, whereas worms are legless.

The larvae spend almost all of their time eating and grow very rapidly. When they become too large for their first suit of clothes and have made certain changes in their bodies, they split the old covering. Then they crawl out of the old suit and secrete another and larger one. This happens several times. We call this process molting, as we do when birds change their plumage. Each stage of larval growth (between two molts) is called an instar.

The larva in its last instar builds about itself a case in which it changes to an adult. It first attaches itself to an object by silk threads which it spins. Some moth larvae then spin a silk cocoon. Our silk clothes are made from the silk taken from cocoons. Inside the silk cocoon the larva builds a pupa case about itself. Most insects build only a pupa case but no silk cocoon.

Inside the pupa case wonderful things take place. The larva must entirely rebuild itself into an adult which is quite different from the wormlike creatures that we have been feeding.

The adults emerge from the pupa cases, lay eggs, the larvae grow and pupate, and the life story is repeated usually one or more times during a season. Many of the moths and butterflies spend the winter in the pupa stage.

Insects are interesting creatures which many people have never learned to enjoy. Having reared one kind of insect at school, we now know how to have great fun rearing many others during the summer.

References

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 308–457.

COMSTOCK, JOHN HENRY: "Introduction to Entomology," Ithaca, New York: Comstock Publishing Company, 1930, pp. 166–206.

**Cornell Rural School Leaflet*, Vol. 19, No. 4: Moths and Butterflies, Ithaca, New York: Cornell University, March, 1926.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 117–132, 179–205.

ELIOT, IDA MITCHELL, and CAROLINE GRAY SOULE: "Caterpillars and Their Moths," New York: D. Appleton-Century Company, Inc., 1902, 302 pp.

*JOHNS, LENA M., and MAY AVERILL: "Moths and Butterflies," Dansville, New York: F. A. Owen Publishing Company, 1930, 127 pp.

LUTZ, FRANK EUGENE: "Fieldbook of Insects," New York: G. P. Putnam's Sons, 1921, 510 pp.

NEEDHAM, JAMES G.: "Elementary Lessons on Insects," Springfield, Illinois: Charles C. Thomas, 1928, pp. 198–204.

PALMER, E. L.: "Field Book of Nature Study," Ithaca, New York: The Comstock Company, 1928, Part III, pp. 21–55.

*PATCH, EDITH M.: Hexapod Stories, Boston: Little, Brown & Company, 1920, 168 pp.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 208–212.

*——— and ———: "Elementary Science by Grades," Book III. New York: D. Appleton-Century Company, Inc., 1928, pp. 19–25.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book I, Philadelphia: J. B. Lippincott Company, 1931, pp. 1–112.

* ——— and ———: "Early Journeys in Science," Book II, Philadelphia, J. B. Lippincott Company, 1931, pp. 143–153.

*——— and ———: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company, 1931, pp. 86–148.

*WEED, CLARENCE M.: "Butterflies Worth Knowing," Garden City, New York: Doubleday, Doran & Company, Inc., 1923, 286 pp.

———: "Insect Ways," New York: D. Appleton-Century Company, Inc., 1930, pp. 1–18.

INVESTIGATING ANT AND HONEYBEE COLONIES

Aims

Enjoyment and appreciation of the remarkable organization and cooperative activities of the social insects. Joy in experimentation and discovery.

Some contribution to the concept that species survive that in their evolution develop characteristics suited to the conditions for existence. Some realization of the process of sexual reproduction and its importance.

Suggestions

Ants are among the most interesting animals to study, and an ant colony can generally be found close to the schoolhouse. If desired, an ant colony can be kept in the schoolroom with a surrounding trough of water, but a more interesting study can usually be carried on outdoors. (Suggestions for securing and keeping ants in the schoolroom will be found on pages 85–86 of the first reference.)

Make as much of an observational study as possible. Note what the ants are doing, where they are going, and what they are carrying or dragging. Discover how the mound of earth was formed. Does each ant go in a different direction, or are there well-established lines of travel? Follow some individuals, and discover their goals. Are materials being transported into or removed from their homes?

Place a small vessel of honey or some other sweet a few feet from the ant burrow, and watch the ants discover it. How do you think that they locate it? Observe whether they go directly toward it or wander about until they finally find it.

Scatter bread crumbs, small bits of meat, fruits, dead insects, grains, and a great variety of other foods near their burrow, and observe their activities. Observe the way in which ants move objects much larger than themselves. Note which they drag into the burrow to use as food.

Place live insects (including ants from other colonies) among the throng about the mouth of the burrow, and observe the reactions.

Place large objects in their paths of travel, and note how they proceed. Carry ants different distances from the nest, and note whether they can find their way home. Fill up the mouth of the burrow with a little dirt, and observe again the next day.

Find an ant colony under a stone or other object. Remove the stone, and watch the workers carrying away the pupae. Where do they take them? Put your hand in among the ants, and see if they will attack it. Can you find any winged queens and kings (males)? Find out when ants have wings. In what ways is the colony like a colony of people? How intelligent do the ants seem to be? Do they change their ways as need arises?

If it is possible to obtain an observation hive (glass), it will prove very interesting to observe the activities of a honeybee colony. Place the observation hive in or against a partly open window so that the bees can come and go, and close off the remainder of the aperture to keep them out of the schoolroom.

Learn to recognize the queen, the drones, and the workers. Observe the workers entering the hive. Where do they carry the pollen? Where must the nectar and resin be carried? Read and observe to find out what the bees do with each of these materials. Observe how the comb is constructed and cemented. Where do they get the wax and cement? What is honey? Observe which cells are filled with honey and which contain eggs or grubs (young larvae). Can you find a large queen cell?

Do the bees agree, or are there signs of conflict as they come in contact with each other in the hive? Mark returning workers with a little red chalk dust, and observe what tasks they perform in the hive. Introduce some other kind of insect into the hive, and note the response. What evidences are there of organization within the colony?

Contributing Learnings

Honeybees and ants are social insects. They live in colonies consisting of males, the female or queen, and the workers. The workers are really females, but most of them cannot lay eggs. When they do lay eggs, the eggs develop into males. Males and queens are usually winged, although the queen ant can shed her wings. The workers in an ant colony are wingless.

The swarms of winged ants that we often see are males and females which have matured and left the colony. After mating, the male soon dies. The female, now able to lay fertile eggs,

makes her burrow, seals it shut, and waits until her eggs are developed and ready to be laid. The eggs hatch into larvae or grubs which are fed on the mother's saliva. When the larvae are grown, they pupate and eventually emerge as small worker ants. They open the burrow and collect food for the queen, for themselves, and for more larvae. They care for the young and do all of the work of the colony.

The organization of a honeybee colony is similar. The young workers, often called nurse bees, carry on the work inside the hive, while the older workers bring in the materials needed. These materials are nectar for making honey, pollen for making bee bread, and resin for making a cement to seal crevices. The honey and bee bread serve as food. Beeswax is secreted by the bees. The young larvae are fed for the first few days on a very rich material excreted from the mouths of the nurse bees and known as royal jelly; after that time, they are fed on honey and beebread. The young are reared in the cells of the honey comb.

To produce queens, the workers tear out the walls separating three adjoining cells and destroy two of the three eggs. The larva hatching from the third egg is fed on royal jelly alone and develops in the large cell into a queen bee. When new queens emerge from the pupa cells, there is a struggle. The old queen is generally driven from the hive. Some of the workers go with her, and a swarm results. A queen bee cannot found a colony alone, as can a queen ant. If several new queens emerge at the same time, they fight until only one remains. The males or drones are killed or driven from the hive by the workers after early summer. A strong colony consists of many thousands of bees.

The division of labor and specilization developed by bees and ants has proved a very successful arrangement. Ants have become the most abundant animals living in the earth. The many devices and arrangements that seem to us so queer are necessary for survival in social life.

While the honeybees and ants have developed a marvelously complex plan of life, it is always carried on in the same way. They seem unable to reason much or to meet new problems. When unusual dangers arise in the form of enemies or cold or food shortage, they are unable to plan to meet the new situations and are destroyed. However, they multiply so rapidly and have become so well adapted to their environment that large numbers

continue. If unfavorable conditions cut down their numbers for a time, they multiply rapidly when conditions improve and soon become as numerous as ever.

References

CRAIG, GERALD S.: "Tentative Course of Study in Elementary Science for the Horace Mann School, Grades III and IV," New York: Teachers College, Columbia University, 1927, pp. 85–86.

*——— and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 131–180.

*DUPUY, WILLIAM ATHERTON: "Our Insect Friends and Foes," Philadelphia: John C. Winston Company, 1925, pp. 122–137.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson and Company, 1928, pp. 145–178.

*FISHER, CLYDE, and MARION L. LANGHAM: "Nature Science," Book II: "Ways of the Wild Folk," New York: Laurel Book Company, 1935, pp. 136–168.

*KENLY, JULIE CLOSSON: "Cities of Wax," New York: D. Appleton-Century Company, Inc., 1935, 250 pp.

*MAETERLINCK, MAURICE: "The Children's Life of the Bee," New York: Dodd, Mead & Company, Inc., 1927, 192 pp.

*PERSING, ELLIS C., and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 8–19.

*——— and C. LOUIS THIELE: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 280–288.

*PHILLIPS, MARY GEISLER, and JULIA MCNAIR WRIGHT: "Nature—By Seaside and Wayside," Book I: "Some Animals and Their Homes," Boston: D. C. Heath & Company, 1936, pp. 25–48.

*——— and ———: "Nature—By Seaside and Wayside," Book II: "Some Animal Neighbors," Boston: D. C. Heath & Company, 1936, pp. 4–37.

*STRICKLAND, RUTH G.: "Bees and Ants," Columbus: American Education Press, 1935, 36 pp.

REARING SOME TOADS TO PROTECT OUR GARDENS

Aims

Development of desirable attitudes toward a much misunderstood form of life.

Experience contributing to better understanding and attitudes concerning reproduction and metamorphosis.

A new avenue of interest and satisfaction.

Suggestions

The short incubation period, the need of overcoming the repugnance for the animal, and its value to us as a destroyer of insects make the toad an especially desirable animal to rear. Moreover, the common American toad will readily deposit its eggs in captivity where the children can observe the process.

Late in April make a trip to a pond or quiet backwater where the toads will have congregated by this time. Listen for the high, sweet, tremulous call of the toads. If you are not able to secure a male and female during this visit, some one can visit the pond at night with a lantern and easily secure a pair, as the toads have a tendency to come to the light.

Place the toads in an aquarium in one end of which the soil and vegetation rise above the water. Bring back from the pond enough water containing vegetation to fill the other end of the aquarium to a depth of three or four inches. Tap water that has stood for a few hours will do. Cover the aquarium with screen or cheesecloth.

Stroke the toads. Observe their behavior in singing. Find out by experiment whether they make warts. Examine the toad's mouth and tongue. Turn some live flies loose in the aquarium, and watch the toad catch and eat them.

Count a few of the eggs laid, and try to estimate the number. Observe the swelling of the gelatinous strings. Notice whether all of the eggs turn black within a day, showing that they have been fertilized and are developing into tadpoles.

Watch the strings of eggs daily as they develop rapidly. Discover how soon the baby tadpoles can be seen in the transparent eggs (usually about the third day). Discover when the tadpoles emerge from the jelly-like strings. Remove the jelly-like masses

containing the unfertilized eggs before they decay and foul the water.

It is best now to carry most of the tadpoles back to the pond in a pail of water. Do not keep more than a hundred unless the aquarium is a large one. The parent toads should also be freed now, although they do not eat their young, as some fishes and other animals do.

Examine one of the newly hatched babies. Note the two suckers where you expect to find a mouth. Observe that they cling to the vegetation and sides of the aquarium by means of sticky substances secreted by the suckers.

Watch for the gills to appear, and discuss their use.

Discover how the baby tadpoles swim. Note the growth, especially of the head. Observe the disappearance of the gills as they are covered by a membrane which grows back from the head.

When the tadpoles begin to forage about the aquarium in search of food, examine one carefully again. Notice that the mouth is now open and has horny jaws with which it scrapes the algae from the sides of the aquarium. From now on, it is necessary to keep the water well supplied with pond scum if the tadpoles are to thrive.

Compare the repeated swallowing motions of the tadpoles, even when they are not eating, with those of fishes. Discuss the meaning of this act.

Watch the development of the legs and the disappearance of the tail. Note when the developing toads seem to prefer to remain out of the water. Explain to the children the change to lung breathing.

As soon as the tails disappear, the toads are ready to be placed in the gardens. Find out which families wish the toads to protect their plants. Let the children carry the toads home in ice-cream cartons or other boxes containing a small amount of moist earth. Instruct the children to release the toads in a moist place.

In the event that school closes while the toads are still in the tadpole stage, they can be given to some child to rear or returned to the pond. The project will not have failed in either case, as most of the educational values will have been achieved. The children can feel that they have largely accomplished their purpose, as it is likely that most of the tadpoles would have been eaten by predators had they hatched in the pond.

Contributing Learnings

Toads are valuable animals. They destroy many harmful insects. They live about our home grounds and do not seem to be afraid of us.

Toads spend the winter burrowed in the ground. In April they come forth and travel to the ponds and quiet shallow parts of streams. The males arrive first and are soon joined by the females. The females are larger and have light-colored throats, while the throat of the male is black.

They mate, and the female soon lays eggs in the shallow water among the vegetation. They will lay eggs in an aquarium. The eggs are in a single row in long jelly-like strings. (Frog eggs are in jelly-like masses instead of strings.) Each toad lays several thousand eggs. Each egg has protecting jelly-like coatings. These coats and the entire jelly-like mass absorb water and swell, becoming much larger soon after they are laid.

If the water is warm, the eggs begin to develop rapidly. Within a day the fertile eggs become black as the tadpoles develop within them. Eggs that the male did not fertilize remain light colored and decay after a time.

In three or four days the tadpoles can be seen in the eggs. They seem to consist of a head, which is really head and body, and a tail. In another day the tadpoles leave the jelly-like strings. They are black and very tiny. Instead of a mouth such as mother and father toad had, each tadpole has two small openings which are called suckers. From the suckers a sticky substance is secreted which enables the baby tadpoles to cling to the sides of the aquarium, to the deserted jelly-like strings, and to plants.

Soon the fingerlike gills grow out just behind the head. These gills are not exactly like the gills of a fish but are used for the same purpose—to take in air from the water. Later, a skinlike membrane grows over the gills. After the gills are enclosed, the tadpole must swallow the water to force it over the gills as fishes do.

The tadpoles grow rapidly, and soon a large mouth appears. They now swim about the aquarium, eating the algae and slimy water growths. The jaws are horny, enabling the tadpoles to scrape the green algae from the sides of the aquarium.

In a few weeks the tadpoles begin to develop into toads. The hind legs appear first, although the front legs are growing beneath

the skin at the same time. The tail also begins to disappear. Tadpoles do not drop their tails when they become toads. Instead, they absorb their tails and use them to build toad parts. The eyes are large now and, like those of the parents, are raised and prominent. But the skin of the developing toad is still smooth.

The gills have now been replaced by lungs. Lungs cannot take in air from the water, so the toads begin to remain out on the leaves and wet soil.

They are now about ready to begin their life on shore. From now on, they feed on live insects which they catch with their sticky tongues. The tongue is attached at the front, instead of at the back, as ours is. It flies out quickly like a spring and catches moving insects.

The little toads are very interesting fellows. If handled, they often turn over on their backs and play dead for a few minutes. They continue to eat insects and to grow, spending each winter burrowed in the ground. When three or four years of age, they, too, go to the pond in April where they mate and lay eggs. Very few animals live to be old, but the toads that are not eaten by an enemy may live at least thirty or forty years.

Growing toads shed their skins frequently, as do the insects. Toads eat their shedding skins. This seems to be the easiest way to remove the skin.

Toads do not drink with their mouths. They absorb the water through their skins. If kept in a dry place, they shrink and finally die.

Toads sing a great deal from April throughout much of the summer. The song is a high tremulous call which is very sweet and lasts for a few seconds. A lower pitched droning tone is blended with the higher one. Toads can sometimes be heard in the afternoon but almost always in the evenings. Only the male sings.

Toads are among our best and most interesting friends. They are much misunderstood, as they do not cause warts. We should teach others to enjoy and protect the toads.

References

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 75–79.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 181–189.

*Craig, Gerald S., and Agnes Burke: "Pathways in Science," Book I: "We Look about Us," Boston: Ginn and Company, 1933, pp. 186–189.

*——— and Condry, Margaret G.: "Pathways in Science," Book V: "Learning about Our World," Boston: Ginn and Company, 1932, pp. 313–328.

Dickerman, Mary C.: "The Frog Book," Garden City, New York: Doubleday, Doran & Company, Inc., 1908, pp. 63–81.

*Dunn, Fannie Wyche, and Eleanor Troxell: "Mother Nature Series—By the Roadside," New York: Row, Peterson & Company, 1928, pp. 7–38.

*DuPuy, William Atherton: "Our Animal Friends and Foes," Philadelphia: John C. Winston Company, 1925, pp. 9–13.

*Edwards, Paul Grey, and James Woodward Sherman: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 147–152.

Hodge, Clifton F.: "Nature Study and Life," Boston: Ginn and Company, 1902, pp. 274–294.

*Jenkins, Oliver P.: "Interesting Neighbors," Philadelphia: P. Blakiston's Son & Company, 1922, pp. 46–68.

Morgan, Ann Haven: "Fieldbook of Ponds and Streams," New York: G. P. Putnam's Sons, 1930, pp. 368–370.

*Patch, Edith M., and Harrison E. Howe: "Nature and Science Readers," Book I: "Hunting," New York: The Macmillan Company, 1932, pp. 75–81.

*Persing, Ellis C., and Peeples, Elizabeth K.: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 109–113.

*——— and C. Louis Thiele: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., pp. 32–39.

Schmucker, Samuel Christian: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 147–158.

*Teeters, W. R., and Clara M. Heising: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company, 1931, pp. 149–157.

CARING FOR OUR PETS

Aims

Development through the expression of desirable emotions.

Considerate attitudes toward other forms of life.

Some understanding of the needs and ways of animals and experience in dealing with them.

Experience contributing to the concept of the role of intelligence in adaptation.

Suggestions

Almost any animal will do. Dogs, rabbits, cats, ponies, white rats and mice, injured crows or other wild birds, domestic fowls, fishes, frogs, toads, turtles, and snakes are suitable.

Obviously, all of these cannot be kept in our schools as they are now organized. Some of the children will already have assumed at least part of the care of some pet at home. If parents are made to see the value of such an activity, the care of a pet will be given over to the children in many more homes. A dog is probably the best of all pets. If cats are kept, they should be well fed and prevented from ranging at night. Otherwise, the birds in the neighborhood will suffer.

A few small pets can be kept at school, and all of the children at some time or other given an opportunity to care for them. It is unnecessary to impose the care as a task, for children are eager to undertake it, although they may need to be reminded occasionally.

Caring for any pet should include studying its needs and providing as suitable surroundings and food as possible. When any pet is obtained, let the children begin at once to make plans for it. If they are unable to read material concerning its habits and care, they will be eager to hear it read and discuss it. For information of this nature consult the references.

To increase the range of experiences and to prevent the burden of care from accumulating, pets may be released or given to individuals from time to time as new ones are obtained.

Perhaps the greatest single problem in keeping pets at school is that of cleanliness. Unless proper provisions are made, cages soon become unsightly, and the odors offensive. This problem

can be largely solved by the use of soil or cardboard (carton) material on the floors of the cages. The carton material can be removed from time to time with the bedding and burned. If soil is used, it can be changed every few weeks, the used material being added to the flowerbeds outdoors.

Many animals are limited in their food habits, and it will be necessary to study the needs of each kind of pet. The lowering of schoolroom temperatures at night is less of a problem with most animal pets than with growing plants.

Contributing Learnings

Animals are not just friends or foes; they are interesting creatures. The earth is their home as well as ours.

The other animals are much like us. They must have food, water, and a suitable place in which to live. They carry on their activities and seem to be as occupied with them as we are with ours. There is the same interesting event of birth and the growth of the young.

Many of the animals play among themselves. They usually fear us when we first get them and try to escape or defend themselves, but they soon come to accept us naturally if we treat them as fellow creatures. Many people have not learned to enjoy these animals. Some fear them and loathe them, especially such animals as harmless snakes, toads, salamanders, and lizards. But we find interest and joy in all these living creatures when we care for them and learn their ways. They are not vile things but interesting creatures living their unique lives.

The hairy animals are more intelligent than the lower forms of life. For this reason they make the most interesting pets. Dogs are among our most faithful friends. They understand many things. They learn to follow us, play with us, guard our possessions, and share our existence in many other ways.

Each kind of animal has its needs. The more intelligent animals can learn to get along under a wider range of conditions, but the less capable ones have more fixed ways and usually die if the conditions are changed too much. (There is not space here to discuss the habits of the different animals. The specific learnings will vary with the animals kept as pets.)

References

*Bianco, Margery: "All about Pets." New York: The Macmillan Company, 1930, 134 pp.

*COMSTOCK, ANNA BOTSFORD: "The Pet Book," Ithaca, New York: Comstock Publishing Company, 1915, 301 pp.

CRANDALL, LEE S.: "Pets and How to Care for Them," New York: New York Zoological Park, 1921, 303 pp.

DOWNING, ELIOT R.: "Our Living World," Chicago: University of Chicago Press, 1924, pp. 193–202.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 65–71, 245–256.

*——— and ———: "Mother Nature Series," Book III: "In Field and Forest," New York: Row, Peterson & Company, 1928, pp. 97–104.

HODGE, CLIFTON F.: "Nature Study and Life," Boston: Ginn and Company, 1902, pp. 33–44.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III. New York: Mentzer, Bush & Company, 1930, pp. 139–146.

*HYMAN, MARY WATSON, and others: "The Find Out Book," Vol. I, Chapel Hill, North Carolina: University of North Carolina Press, 1934, pp. 8–85.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 94–100.

*SMITH, JEANETTE: "Pets at School," Columbus: American Education Press, 1934, 24 pp.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book I, Philadelphia: J. B. Lippincott Company, 1931, pp. 93–215.

*TRAFTON, GILBERT: "Nature Study and Science," New York: The Macmillan Company, 1927, pp. 227–236.

———: "The Teaching of Science in the Elementary School," Boston: Houghton Mifflin Company, 1918, pp. 82–86.

*WHITE, MARGARET L., and ALICE HANTHORN: "Do and Learn Readers," Book III: "Interesting Things to Know," New York: American Book Company, 1930, pp. 40–42.

HELPING A MOTHER HEN REAR A FAMILY OF CHICKS

Aims

Normal interests and attitudes in the propagation and development of new life.

An avenue of satisfaction commonly lost to all but rural children in the modern age.

Some elementary understanding of phases of reproduction and the needs of living things.

Suggestions

Secure a hen that has shown a determination to set and twelve to eighteen fertile eggs, preferably from chickens of mixed breed to insure variation among the chicks. Examine the hen to see that she is free from lice.

Fence an area against the south side of the school building, where the water will not drip from the eaves, or in some other protected place. (For this activity one teacher used a spare room in the basement where there was no floor.)

Let the children make over a large wooden box into a hen house. Turn the box on one side, and cover the upper side with a piece of oilcloth to make it waterproof. Newspapers may be tacked on the inside to make the house windproof if the weather is still chilly. Leave part of one side open. A small porch over the open side will help to prevent the rain from beating in. Support the house a few inches above the ground by nailing it to strong stakes driven into the soil.

Insert a smaller cardboard or wooden box containing a comfortable nest of straw or excelsior. Nail a stick across for a perch. Place the eggs in the nest, and the hen will cover them and arrange them to her liking.

See that water and fresh leafy foods as well as grain are kept in the pen during the nesting period. Do not feed baby chicks for the first two days after they hatch. Before the first feeding give them water from which the chill has been removed, dipping their beaks to teach them to drink. Keep water before them now at all times, making sure it is not too cold. Spread dry mash on clean boards, and give them an hour to eat. Then remove the food, and darken their house to encourage them to rest. Repeat

two or three times the first day and three to five times the second day, adding finely cracked grain. After two or three days, dry mash may be left in the pen at all times. After four days, add coarse sand or grit, charcoal, moist mash, and green food.

Observe how the mother hen keeps the eggs warm, how she turns them, how often and how long she leaves them, the pipping of the eggs and emergence of the chicks, how the mother hen keeps the chicks warm, how she calls them and trains them, the early down and later development of feathers, hereditary differences among the chicks, learning to fly, etc.

Contributing Learnings

Chickens develop from eggs. Some eggs will not hatch. It is necessary to keep a rooster with the hens to fertilize the eggs, if we wish to raise young chicks. Where unfertile eggs which will keep longer for eating purposes are wanted, roosters are not kept with the hens.

Hen eggs are large, as they contain enough food for the developing chick. The eggs must be kept warm, or the little chicks will not develop.

Many animals such as birds, turtles, snakes, insects, worms, and frogs lay eggs from which the young develop. Some animals keep the eggs inside the body. The eggs develop there into baby animals which are born alive. The eggs of these animals are small. They do not contain so much stored food. Instead, the developing baby animal gets its food from the mother.

Most baby animals require care for a period, although all of the others learn to care for themselves much sooner than we do. Many mother animals work very hard to feed and care for their babies, as our mothers do. Sometimes the fathers help.

Young animals do not grow up to be just like their parents.

Chickens do not have teeth with which to chew their food. The coarse sand and grit that they swallow help in grinding the food.

References

*BEATY, JOHN Y.: "Story Pictures of Farm Animals," Chicago: Beckley-Cardy Company, 1934, pp. 84–100.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 41–44.

*———: "The Pet Book," Ithaca, New York: Comstock Publishing Company, 1915, pp. 188–191.

FABRE, JEAN HENRI: "Our Humble Helpers," New York: D. Appleton-Century Company, Inc., 1920, pp. 3–60.

Hatcheries. (Secure instructions for raising chicks from the nearest hatchery.)

*HYMAN, MARY WATSON, and others: "The Find Out Book," Vol. I, Chapel Hill, North Carolina: University of North Carolina Press, 1934, pp. 59–68.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 92–96.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 124–130.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book I, Philadelphia: J. B. Lippincott Company, 1931, pp. 38–44.

*TROXELL, ELEANOR, and FANNIE WYCHE DUNN: "Mother Nature Series," Book I: "Baby Animals," New York: Row, Peterson & Company, 1928, pp. 7–10.

U. S. Department of Agriculture, *Farmers' Bulletin:* Incubation of Hens' Eggs, No. 1106; Care of Baby Chicks, No. 1108; Management of Growing Chicks, No. 1111; Incubation and Brooding of Chicks, No. 1538 Washington, D. C.: Superintendent of Documents.

STALKING BIRDS TO LEARN THEIR WAYS

Aims

Joy in observation and discovery. Interest in bird life.

Appreciation that leads to desirable attitudes toward conservation.

Experience contributing to a concept of the interdependence of life.

Suggestions

Stories of the lives of Indian children afford a good means of interesting pupils in stalking wild things to learn their ways. Once they get the idea, it proves a delightful game of discovery.

If only a short time is devoted to the activity, late April and May will yield the richest returns.

Select any common birds that are not too shy and that happen to be abundant in the vicinity, such as robins, pigeons, doves, wrens, grackles, nuthatches, blue jays, downy woodpeckers, flickers, orioles, or grosbeaks.

Teach the children to move slowly and to remain "still as an Indian" watching the birds.

It is necessary at times to direct the observations of young children by suggesting things to discover. Children like to do this sort of thing so well that they will carry on the activity at home as well as at school.

Find how close one can approach without frightening the birds away. Discover whether they are more afraid of our voices or our movements. Make different types of sounds and movements to see which frighten them. Try to account for their fear of sudden movements and sounds of approach. After learning how to stalk birds, children are ready to make other discoveries.

Learn to recognize male and female. Discover whether they are in pairs. Are they nesting? Learn the habits of each. Do both sit on the nest and feed the young?

Watch birds move about. Are they often seen on the ground? Do they run or hop? Are they tree birds? Do they travel over the trunk of the trees in search of food or cling to the small branches? How do they keep from falling? Describe their flight.

Watch them searching for food. What are they finding? Are they helping us or doing harm?

Listen to the sounds that they make. Do both male and female sing? How many different songs does each bird sing? When do they sing these songs? Listen for the call and answer. Are they on the same pitch? Listen for sounds during flight. What sounds do they make when they are startled? Interest children in listening to the sunset, daybreak, and sunrise bird sounds.

Discover how birds take a bath.

Try to observe and describe the building of a nest. Be very careful not to disturb the nest or frighten the birds. Observe the eggs and the development of the young. Discover how the young are fed. Watch the young learn to fly.

Each child should report his discoveries to the group. Every child should discover something. Encourage and stress accuracy in reporting observations.

Each child will not make all of these discoveries, but the activity should be continued until it results in opening a new zestful interest in watching birds.

Contributing Learnings

Birds are attacked by many enemies which swoop down or pounce upon them. They have come to fear sudden movements and sounds of approach. By remaining still we can discover their ways.

The male birds usually have brighter colors than the females. The males of some species arrive earlier in the spring than the females. Most of the birds are in pairs quite early in the spring. In some cases the male and female birds take turns at sitting on the nest to keep the eggs warm. Quite commonly, both parents bring food for the young. The food is generally thrust far down the mouths of the clamoring young birds waiting with upstretched necks to receive it.

Some birds such as robins and pigeons are commonly seen on the ground where they hop or run about in search of seeds, worms, and insects. Others such as nuthatches and creepers search the trunks and branches of trees for insects while clinging and balancing with marvelous skill.

Birds make many kinds of sounds. Some birds sing a variety of songs. The most varied singers are the catbirds and mocking birds (in the south). Robins sing definite sunrise and sunset songs. Some birds call and answer each other. The mate's

answer is frequently on a slightly different pitch. When disturbed, many birds make a startled sound. Flight sounds of robins, flickers, and jays are common.

Some birds such as hawks sail about searching for food. Such birds as swallows and flycatchers dart about with flashing speed catching insects on the wing. Crows flap their wings slowly.

Woodpeckers, nuthatches, and many other tree birds feed largely on insects. Other birds such as the junco and house sparrow eat large quantities of weed seeds. Many birds eat both plant and animal foods. Birds are important helpers as well as interesting friends.

The habits of birds are so interesting and varied that no one need lack for something interesting to do in his spare time.

(Consult the references for further information regarding the habits of the different birds which cannot be described here.)

References

*ALLEN, ARTHUR A.: "American Bird Biographies," Ithaca, New York: Comstock Publishing Company, 1934, 238 pp.

BALL, ALICE E.: "Bird Biographies," New York: Dodd, Mead & Company, Inc., 1927, 291 pp.

*BEAUCHAMP, WILBUR L., GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book I, Chicago: Scott, Foresman & Company, 1933, pp. 53–66.

*DUPUY, WILLIAM ATHERTON: "Our Bird Friends and Foes," Philadelphia: John C. Winston Company, 1925, 319 pp.

*EDWARDS, PAUL GREY, and JAMES WOODWARD SHERMAN: "The Nature Activity Readers," Book II: "The Outdoor Playhouse," Boston: Little, Brown & Company, 1931, pp. 3–14.

*——— and ———: "The Nature Activity Readers," Book III: "The Outdoor World," Boston: Little, Brown & Company, 1931, pp. 3–20.

HAWKSWORTH, HALLAM: "A Year in the Wonderland of Birds," New York: Charles Scribner's Sons, 1925, 245 pp.

HERRICK, FRANCIS HOBART: "The Home Life of Wild Birds," New York: G. P. Putnam's Sons, 1901, 137 pp.

MATHEWS, F. SCHUYLER: "Field Book of Wild Birds and Their Music," New York: G. P. Putnam's Sons, 1904, 325 pp.

*PATCH, EDITH M.: "Bird Stories," Boston: Little, Brown & Company, 1912, 195 pp.

PEARSON, T. GILBERT: "The Bird Study Book," Garden City, N. Y.: Doubleday, Doran & Company, Inc , 1917, pp. 21–41.

*ROBERTS, THOMAS S.: "Birds of Minnesota," Minneapolis: University of Minnesota Press, 1932, 2 vols.

*———: "Bird Portraits in Color," Minneapolis: University of Minnesota Press, 1934.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book III, Philadelphia: J. B. Lippincott Company, 1931, pp. 61–71.

KEEPING A DIARY OF A BIRD FAMILY

Aims

An absorbing avenue of interest.

Intimate acquaintance with and affection for birds which lead to attitudes of conservation.

Suggestions

It is necessary to find a pair of birds beginning to nest in a place accessible for observation. Only an open nest so placed that the children can observe all of the happenings without disturbing the bird family is entirely satisfactory.

A robin's or dove's nest in a crotch of a tree outside the window is ideal. Nests on the ground or in low bushes are also suitable, but more care is necessary in order not to disturb the family.

Before beginning the observations and diary, it is important to arouse such an interest in the welfare of the bird family that the children will curb their desires to spy upon it too often or to approach too close.

The diary should be the natural outgrowth and not the major purpose of the activity. The form of the diary will depend upon the language ability of the children. Art and literature should be utilized to provide the integrated interactions possible through this absorbing activity.

Make observations daily. Discuss and record them. When the nest is being built, and later when the young are being fed, the class should spend a number of longer periods quietly observing the activities. Count the number of trips made by the parent birds during these periods.

Follow the doings of the bird family through the nest building, the incubation of the eggs, and the rearing of the young until they leave the home. Without overindulgence of imagination, these experiences will grip the children as intensely as could a well-written story of a human family. Nearly all of the absorbing activities of life will come into the diary of the bird family—even tragedy and comedy.

Contributing Learnings

(While there is much that is common to the stories of most bird families, and especially within any species, the story of any individual family can be compiled only by observation. The teacher will find the references useful in directing the observations.)

References

DUGMORE, A. RADCLYFFE: "Bird Homes," Garden City, New York: Doubleday, Doran & Company, Inc., 1920, 183 pp.

*DUPUY, WILLIAM ATHERTON: "Our Bird Friends and Foes," Philadelphia: John C. Winston Company, 1925, 319 pp.

*DUNN, FANNIE WYCHE, and ELEANOR TROXELL: "Mother Nature Series," Book II: "By the Roadside," New York: Row, Peterson & Company, 1928, pp. 73–107.

HERRICK, FRANCIS HOBART: "The Home Life of Wild Birds," New York: G. P. Putnam's Sons, 1901, 137 pp.

*HOLTZ, GRACE M., and JENNIE HALL: "Elementary Science," Book III, New York: Mentzer, Bush & Company, 1930, pp. 121–130.

*PERSING, ELLIS C., and ELIZABETH K. PEEPLES: "Elementary Science by Grades," Book I, New York: D. Appleton-Century Company, Inc., 1930, pp. 97–108.

*ROBERTS, THOMAS S.: "Birds of Minnesota," Minneapolis: University of Minnesota Press, 1932, 2 vols.

*TROXELL, ELEANOR, and FANNIE WYCHE DUNN: "Mother Nature Series," Book I: "Baby Animals," New York: Row, Peterson & Company, 1928, pp. 107–120.

STARTING A BIRD HAVEN

Aims

To open new avenues of satisfaction in construction, plant culture, and observing birds.

To foster appreciation of bird life and the spirit of conservation and cooperation through participation in a group undertaking to attract and provide for birds.

Suggestions

The desire to provide a haven for birds comes as the result of satisfying experiences with them and should follow other bird projects. It is a sufficiently large undertaking to enlist the efforts of the entire school.

Decide upon a location somewhere on the school ground. There must be protection from winter winds and storms. If there are heavy plantings of evergreens and other trees and shrubs on the grounds, it is best to choose this site for the haven. Otherwise, such a planting must be made. The next consideration in locating the haven is availability for observation. If it can be placed where the birds can be observed from within the school, so much the better. It should be well protected on the north and west sides by dense plantings.

The haven is to provide shelter, nesting sites, food, water, and seclusion.

Some birds will build in the trees and shrubs. Birdhouses of a naturalistic type should be constructed and placed at proper heights in the haven for others. (See the references on building birdhouses for size of openings, heights, etc.)

It is important to start some of the plants that provide food for the fruit-eating birds. (See the suggestions for the activity "Finding What Foods the Birds Like Best." U. S. Department of Agriculture *Farmer's Bulletin* 1239 contains a list of the wild fruits preferred by birds and other useful suggestions.) Transplant a number of the food plants to the haven as early in the spring as possible from some spot in the vicinity where they are abundant. Supplement the growing foods with a food tray which can be kept filled with suet, waste grain, etc. Interest pupils in

observing and reading about the habits of the birds that they hope to attract in order to discover how to provide for them.

A birdbath is an important part of the haven, as it provides drinking water as well as a place to bathe. Suggestions will be found in the references for building birdbaths. Any shallow container will do, but it may as well be attractive. The important consideration is that the water be very shallow at one edge.

If no spot is available on the grounds where a suitable windbreak is already planted, do not be discouraged. Start the undertaking this spring, and let succeeding classes continue it. There ought to be some such cumulative undertakings in every social group.

Contributing Learnings

Our bare school grounds and open lawns do not supply the needs of birds. The birds that remain during the winter need shelter and food. Even the summer birds seek places sheltered from enemies, sun, and storms.

Perhaps the greatest attraction for birds is food. If we have the foods that they prefer, we are almost certain to have birds. Studies have shown that birds become more numerous if their food is abundant for a few years. Many of the natural foods of birds have been destroyed.

Birds have many enemies. They like to hide their nests. Dense plantings usually contain more nests than openly spaced ones.

The distribution of birds is not accidental. We can attract birds if we study their lives to discover what they need and take steps to provide it.

As a rule birds prefer wild fruits to cultivated ones. By planting an abundance of wild foods, we not only attract birds to our schools and homes, but we help the community by preventing some of the damage done by birds to the fruit crops. Many of the birds attracted to the haven destroy insects which would attack our gardens, field crops, and other possessions.

Birds are interesting fellow creatures. They have much in common with us. They are the only animals other than our own mammal group that are warm-blooded and remain active companions throughout the year. Only they and ourselves have developed song to any marked extent. To have them about us,

where we may observe their ways and befriend them, is one of the abiding joys of life.

References

*Gehrs, John H.: "Nature Study," Book I, New York: American Book Company, 1929, pp. 74–81.

Pearson, T. Gilbert: "The Bird Study Book," Garden City, New York: Doubleday, Doran & Company, Inc., 1917, pp. 214–238.

*Persing, Ellis C., and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 202–208.

*——— and John A. Hollinger: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 97–105.

Trafton, Gilbert H.: "Bird Friends," Boston: Houghton Mifflin Company, 1916, pp. 223–270.

U. S. Department of Agriculture *Farmers' Bulletin*, 1239, Washington, D. C.: Superintendent of Documents.

PROTECTING A WILD-FLOWER NOOK

Aims

Interests, attitudes, and knowledge which lead to conservation and intelligent enjoyment of a resource that is rapidly disappearing in many localities.

Training in social responsibility.

Suggestions

Before most of the wild flowers come into bloom, find by inquiry and investigation the location of the nearest spot where they abound.

Begin class excursions to this nook about the time when most of the wild flowers are coming into bloom, usually sometime in April or early May. Go prepared to enjoy the flowers in various ways without picking them. Take along a set of plates of the wild flowers, and identify the flowers from the lifelike colored illustrations. Enjoy the odors of the different species. Go prepared with pencil, paper, and crayons or water colors. Try to draw and color the flowers. Have a small camera with you to take pictures of the beauty spot and some of the most interesting flower groups. Watch the insect visitors. Observe whether they are carrying the pollen. Take along poems of spring and of wild flowers to read here in the wild-flower nook. Compose a poem about this spot and its inhabitants. Write the first part of the story of your visit to this wild-flower nook. Plan a sign to be put up on this spot asking all visitors to leave the flowers on the stem, that everyone may enjoy them and that they may produce seeds.

Pick only one blossom as an experiment to discover what becomes of the wild flowers when we take them for bouquets. Carry it in the hand back to the school, and note its condition.

Prepare the sign asking people to spare the wild flowers, secure permission from the owner of the land, and install it in the wild-flower area.

Write to the Wild Flower Preservation Society for free material. Post the cartoons and other appeals on a bulletin board together with flower plates of some of the flowers most in need of protection. Write to your state department of conservation

for a list of flowers especially needing protection. Be sure that flower plates of these, and of the state flower, are among those on your bulletin board. All children in school should become familiar with these species. Ask the editors of the local papers to reprint the list in order that all people in the community may know them.

Make frequent visits to the wild-flower nook to enjoy the flowers and to discover the changes that have taken place. At each visit inspect carefully to see which flowers have produced their seeds and to note whether any have been molested. Continue until the spring flowers are past the blooming stage. Notice that summer flowers are taking their places but that these are more abundant out in the open areas.

Contributing Learnings

Flowers are nature's way of producing seeds and continuing the plants on the earth. It is true that some plants have other methods of starting new plants underground. Picking, digging, and pulling plants have caused many kinds of flowers nearly to disappear. While some flowers such as the early showy ones of violets never produce seeds, it is much better citizenship to leave all wild flowers where others may enjoy them and to grow the ones that we wish for cutting.

Anyone wishing to grow wild flowers for any purpose should secure the seeds or plants from growers and not disturb the disappearing supply of wild ones.

Many people do not realize that they are causing the wild flowers to disappear by picking and digging them. It is our duty to teach others to protect them.

Most of the spring wild flowers are delicate plants. They wilt quickly when picked and are usually thrown away after being carried a short distance. People who pick wild flowers have not learned the ways to enjoy them most.

Flowers mean much to insects as well as to us. They furnish food for bees, ants, flies, and other small visitors, who, in turn, pollinate the plants and enable them to multiply.

Only by working together as a group can we conserve our resources. So much of the land that once grew wild flowers is now cultivated and heavily pastured that it is very important to save the flowers in the few remaining undisturbed areas.

References

*"The Book of Wild Flowers," Washington, D. C.: The National Geographic Society, 1933, 243 pp.

*Gehrs, John H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 148–152.

*House, Homer D.: "Wild Flowers," New York: The Macmillan Company, 1934, 362 pp.

*———: Wild Flowers of New York, *Memoir* 15, Albany, New York: University of the State of New York: 1923, 362 pp.

*———: Color plates (264) from *Memoir* 15, Albany, New York: University of the State of New York, 1923.

Keeler, Harriet L.: "Our Early Wild Flowers," New York: Charles Scribner's Sons, 1931, 252 pp.

*Mathews, F. Schuyler: "The Book of Wild Flowers for Young People," New York: G. P. Putnam's Sons, 1923, 387 pp.

*Persing, Ellis C., and Elizabeth K. Peeples: "Elementary Science by Grades," Book II, New York: D. Appleton-Century Company, Inc., 1928, pp. 219–223.

*——— and ———: "Elementary Science by Grades," Book III, New York: D. Appleton-Century Company, Inc., 1928, pp. 172–178.

*——— and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 270–276.

*——— and C. Louis Thiele: "Elementary Science by Grades," Book V, New York: D. Appleton-Century Company, Inc., 1930, pp. 248–254, 270–276.

*——— and John A. Hollinger: "Elementary Science by Grades," Book VI, New York: D. Appleton-Century Company, Inc., 1930, pp. 310–324.

Wild Flower Preservation Society, Inc., National Headquarters, 3740 Oliver Street, Washington, D. C. (several publications).

MAKING A WILD-FLOWER SURVEY

Aims

Greater enjoyment of wild flowers.

Appreciation and knowledge which lead to conservation of wild flowers and a desire to restore what has been lost through ignorance and ruthlessness.

Suggestions

Raise the question as to whether spring wild flowers are abundant in the wooded areas of the vicinity, and interest the children in making a survey to settle the question. The time to make the survey will vary with the latitude. In the northern states it is early in May.

Post the pictures of the well-known spring wild flowers of your region in a conspicuous place in the schoolroom. The plates from "Wild Flowers of New York," by House, are especially beautiful.

To a tin can or pot of good wood loam transplant one specimen of each wild flower discovered, and keep the plants at school in order to become acquainted with the species before undertaking the survey. Take them from an area where they are most abundant. After the survey, transplant them to a similar habitat in the woods where they are not abundant at present.

Let the pupils make individual surveys of areas that they have opportunity to visit. Decide upon some form for taking the data concerning each wild flower found. They may be recorded simply as rare, common, or very abundant. While this is not objective and varies somewhat with the judgment of the pupils, it will serve to reveal the situation in a general way. A system of making counts or of ranking the flowers as to abundance can be used with older children. Make at least one or two group field trips to add further data and to check up on the observations.

Bring all of the data together, and discuss them. Take into consideration the fact that flowers require different conditions. If you can secure a local map, let the children show the results of the survey on it in some suitable form. Dotting with colored pencils will show variations in abundance.

Draw general conclusions from the survey as to which flowers need special protection. Discuss why the wild flowers are disappearing and what to do about those which are almost extinct. Let the children prepare a report of the general findings of the survey and get it published in the local papers. Learn the state law for the protection of wild flowers. Get the editor to print it, also, as most persons do not know its provisions. Consider what changes are needed in the law and how it could be made more effective. The project should lead to a further experience in starting from seeds the species of wild flowers that are becoming rare in the community.

Contributing Learnings

The spring wild flowers are short-day plants which bloom in the woods before the trees leaf out. They are quite fragile as compared with the flowers that bloom along the roadsides in summer and fall. Most of them require a rich moist soil with plenty of leaf mold or other organic matter.

When the trees are cut, the taller, ranker growing sun plants crowd out the delicate wild flowers of the forest. Wild flowers have been destroyed in so many regions by cutting off the forests that there remain only small portions of the original area suitable for them.

In these restricted areas they have been largely destroyed by the hordes of people who, with rapid transportation available, visit these remaining beauty spots to dig up and to pick the wild flowers.

Many of our most loved wild flowers have all but disappeared except in remote places.

Laws for protection of wild flowers are inadequate. At least two states—Arizona and California—have placed signs along the highways prohibiting all picking and digging of wild flowers. Our present laws would be more effective if people were acquainted with their provisions and the need for conservation. Education along this line is badly needed. People are more ignorant than ruthless. It is our duty to help others to understand.

Wild flowers can be grown from seed. In this way we can introduce them again. Persons wishing wild-flower gardens should purchase seeds and start the plants in this way and not dig them from the wilds. Restoring the forests will make more places for wild flowers to grow.

References

BLANCHAN, NELTJE: "Wild Flowers Worth Knowing," Garden City, New York: Doubleday, Doran & Company, Inc., 1923, 270 pp.

*"The Book of Wild Flowers," Washington, D. C.: The National Geographic Society, 1933, 243 pp.

COMSTOCK, ANNA BOTSFORD: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 528–595.

DOWNING, ELLIOT R.: "Our Living World," Chicago: University of Chicago Press, 1924, pp. 235–308.

*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 148–152.

*HOUSE, HOMER D.: "Wild Flowers," New York: The Macmillan Company, 1934, 362 pp.

*———: Wild Flowers of New York, *Memoir* 15, Albany, N. Y.: University of the State of New York, 1923, 362 pp.

*———: Color plates (264) from *Memoir* 15, Albany, N. Y.: University of the State of New York, 1923.

KEELER, HARRIET L.: "Our Early Wild Flowers," New York: Charles Scribner's Sons, 1931, 252 pp.

*MATHEWS, F. SCHUYLER: "The Book of Wild Flowers for Young People," New York: G. P. Putnam's Sons, 1923, 387 pp.

PARSONS, FRANCES THEODORA: "How to Know the Wild Flowers," New York: Charles Scribner's Sons, 1924, 346 pp.

*PATTERSON, ALICE JEAN: "Nature Study and Health Education for Sixth Grade," Normal, Illinois: McKnight & McKnight, 1927, pp. 174–180.

*REED, CHESTER A.: "A Guide to the Wild Flowers," Garden City, New York: Doubleday, Doran & Company, Inc., 1922, 232 pp.

*STACK, FREDERIC WILLIAM: "Wild Flowers Every Child Should Know," New York: Grosset & Dunlap, 1909, 411 pp.

*TEETERS, W. R., and CLARA M. HEISING: "Early Journeys in Science," Book II, Philadelphia: J. B. Lippincott Company, 1931, pp. 1–10.

*TRAFTON, GILBERT H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 305–315.

WATCHING FLOWERS FORM FRUITS

Aims

A new avenue of interest in watching the flowering and fruiting of plants, especially of the plants that we grow for their fruits.

Some understanding of the nature and importance of sex and the process of reproduction.

Suggestions

Select some plant with easily observed flowers and fruits. Among the house and greenhouse plants easily obtainable, Jerusalem cherry or one of the other peppers is a good choice. The bloodroot is perhaps the most suitable early spring wild flower for this study. Cherries are among the easiest trees to study. Any plant that flowers and fruits early will do, but it is important to select a plant with reasonably conspicuous flowers and simple fruits.

Let the children find all of the parts of the flower. They can mount and label them or prepare a greatly enlarged labeled drawing of the flower for the schoolroom.

Discover whether the pollen sacs of the anthers have burst open and are shedding their pollen. Try blowing the pollen from ripe anthers to find whether the plant is likely to be wind pollinated. Insert a pencil to discover whether pollen would adhere to insect visitors. Let the children discover what is in the ovary. They should be told that each ovule contains an egg, as they cannot see it. Find a stigma covered with pollen, and explain to the children that a tube grows from the pollen grain down the pistil through which the sperms swim to the egg. Explain fertilization.

Find a partly developed fruit. Look for each of the flower parts, trying to decide what has become of them. Cut the fruit open. Work out the duties of each flower part.

Watch the entire process of forming a fruit, and keep a daily record of the process. Note when the bud opens, when the flower is ready for pollination, and when the petals drop and the style and stamens wither away. Watch the growth of the fruit and the ripening. Cut open a fruit that appears to be ripe. Cut

through the seed to find whether it is solid and mature inside or soft and milky. With a lens look for the baby plant.

Aside from the matter of fertilization, which is too difficult for children to comprehend unaided, let them discover each step in the formation of fruits. Make only such suggestions for procedure as may prove necessary. Recognize every discovery with encouraging commendation.

Contributing Learnings

Flowers develop from buds. The flower parts are present in the buds. If the plant has accumulated enough food, the buds open when given warmth and moisture.

The flower parts (sepals, petals, stamens, pistil) are attached to the swollen end (receptacle) of the flower stalk (pedicel).

The sepals protect the other flower parts, especially before the flower bud opens. Experiments seem to indicate that showy petals attract insects. The nectar which insects also want is usually near the base of the petals. The stamens bear the pollen in anther sacs at their summits. In the ovary (swollen base of the pistil) are the ovules.

Each ovule contains an egg capable of growing into a baby plant if fertilized by a male cell called a sperm.

Most of our plants are insect pollinated, but some depend upon the wind. Pollination is the transfer of pollen from the anthers to the stigmas (tops of the pistils). Pollination is not fertilization, but without it fertilization could not take place. The stigma is often sticky, sometimes feathery. This causes the pollen grains to cling to the stigma.

After the pollen grain reaches the stigma, it absorbs water and begins to grow a tube inside the style of the flower. It gets its food from the pistil. Each pollen grain grows one tube down to one ovule. In the pollen tube, sperms or male cells are formed. A sperm unites with the egg in the ovule. This is fertilization.

The fertilized egg grows into a baby plant in the ovule. The ovule, in the meantime, grows into a seed containing the baby plant, while the ovary grows into a fruit containing the seeds.

The other flower parts usually wither and drop.

The pollen grain may come from the stamens of the same flower, from another flower on the same plant, or even from a different plant. Many more pollen grains may be brought to the pistil than there are eggs to be fertilized. In such cases the pollen

tubes from other similar flowers usually grow more vigorously than those which develop from its own pollen, and accomplish cross-pollination. Only very closely related plants will cross-pollinate readily.

After fertilization takes place, the plant sends most of its food into the developing fruits and seeds. Flowers wither away, and few new ones form.

By picking off the anthers of our house plants and preventing pollination, we can often extend the life of the blossoms and cause the plants to bloom more nearly continuously.

We depend upon this process for our foods and the continuation of many forms of life. Reproduction is much the same in plants and animals.

References

Coulter, Merle C.: "The Story of the Plant Kingdom," Chicago: University of Chicago Press, 1935, pp. 206–231.

*Persing, Ellis C., and Edward E. Wildman: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 240–247.

Schmucker, Samuel Christian: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 218–246.

Textbooks of botany.

Trafton, Gilbert H.: "Nature Study and Science for Intermediate Grades," New York: The Macmillan Company, 1927, pp. 305–315.

GARDENING THE PLAYHOUSE

Aims

A desire to make each home and school beautiful and some knowledge and experience essential to the undertaking.

A keen interest in growing plants.

Suggestions

A playhouse is a good piece of equipment in any school. If none is available, find out whether it is feasible to build one as part of the activity program. For the more difficult tasks the cooperation of some older pupils can usually be obtained. The construction of the playhouse is in itself an excellent activity involving many principles of science. It can also be the center for many creative activities in other fields.

Locate the playhouse in some part of the playground where it can be kept permanently or whither it is to be returned each time when not otherwise in use.

Talk over the purposes to be accomplished in gardening the playhouse, such as shade, winter beauty, attraction of birds, softening the angles of the building, improving the general view by framing it with trees, fitting the house to the lawn with foundation planting, privacy, succession of flowers, etc.

Visit some well-planned homes to get ideas. Look over simple landscaping plans. Draw plans until you have decided what and where you will plant.

Visit shrubs, trees, and perennial herbaceous plants. Read about them in books and nursery catalogues. Choose the few that you will plant.

Find out whether any of the homes in the community have any young plants of these species that they do not want. Purchase the evergreens in the young transplant size for a few cents each. Plan to propagate from seeds or cuttings the other species needed.

Begin planting with what you have. Secure some black dirt if the soil is poor. Do not let the roots of the plants dry out in handling. Dig large holes. Tramp the soil well about the roots. Crown, and water. (See the directions for the activity "Planting a Tree" for more definite planting instructions.)

It is better to garden a large playhouse outdoors, but a very interesting activity can be carried on indoors if the playhouse or sufficient space on the grounds for the gardening is lacking.

Lacking a large playhouse, locate a small model of a house or any toy house constructed of wood or carton on the sand table, leaving front-, side-, and backyard space. Construct steps of wood blocks. Lay out the walks, and construct them of stones, wood blocks, cement, or any other convenient material. If the house is unattractive, let the children paint and decorate it. Plant barley for a quick lawn.

If the shrubs are not yet in leaf or blossom, let the children cut small twigs of red and yellow dogwoods, fruiting twigs of snowberry and rose, and small evergreen twigs to give the place a winter beauty. Small branches of trees may be used to represent trees and to frame the view. A very few evergreen branches may be used as individual trees.

To keep the twigs and branches fresh and attractive, place each in a small container of water embedded in the sand. Large vials are very suitable for the purpose and are inconspicuous.

Let the children plan the arrangement. If they lack ideas, visit a few well-gardened homes to get ideas.

As the shrubs come into flower and leaf about the school and homes, add small twigs to the gardening of the doll house. This may necessitate rearrangement, but the children enjoy planning new schemes of gardening as their knowledge and ideas grow. A few low, early-blooming herbaceous flowers may be added.

In order that the new specimens may be received in good condition, show the children how to cut (not break) the twigs and how to wrap them in wet paper (surrounded by heavy dry newspaper) to carry them to school.

Keep a record of the shrubs in the order of their blossoming. Plan shrubs for the school ground to provide continuous flowering. Plant a few shrubs. Many shrubs multiply so rapidly that parents will be glad to contribute young plants.

Discuss the various ways in which plants add beauty.

Compare the shrubs with the trees. Note how the kinds of shrubs differ from one another. Compare the flowers and fruits of the different kinds.

Press a few of the flowers of the common shrubs, and mount them to add beauty to the schoolroom throughout the year.

Plan planting to be done at home.

Contributing Learnings

Trees are tall woody plants with usually only one stem. Shrubs are lower woody plants with many stems arising at or near the ground. Herbs are not woody.

Trees are used on the home and school grounds to frame the view of the building in a pleasing manner, to provide shade, to add points of interest and beauty, and, in some cases, for their fruits. Shrubs are used to merge the views of the building and lawn, to cover ugly foundations and other unsightly objects, to soften angles of the building and grounds, to afford flowers throughout the season and beauty all year, and to attract birds by their fruits. Herbs are used as borders along the shrubs, to furnish beauty of color on the grounds, and to furnish cut flowers.

Some plants are evergreen and are, therefore, especially important for beauty during winter.

Plants are selected for their shape, leaves, colored stems, and attractive fruits as well as for their beautiful flowers.

Some plants bloom earlier than others, making it possible to have flowers all season long.

Flowers differ in color, odor, shape, and many other ways. Fruits also differ. Some are dry pods whose seeds are eaten by birds. Mountain ash and many shrubs such as elderberry, high-bush cranberry, snowberry, and juniper produce juicy fruits of which many birds are very fond. By planting these shrubs, we can add beauty and, at the same time, attract birds.

Shrubs are not expensive. Any boy or girl can help to beautify his or her home and school. But plants are alive and must have care until they get started.

References

BLAKESLEE, ALBERT F., and CHESTER D. JARVIS: "Trees in Winter," New York: The Macmillan Company, 1926, pp. 89–113.

Cornell Rural School Leaflet, Vol. 15, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1921.

**Cornell Rural School Leaflet*, Vol. 15, No. 2: Woody Plants in Autumn, Ithaca, New York: Cornell University, November, 1921.

Cornell Rural School Leaflet, Vol. 23, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1929.

DEAM, CHARLES CLEMONS: "Shrubs of Indiana," Indianapolis: Department of Conservation, 1924, 337 pp.

*GEHRS, JOHN H.: "Nature Study," Book II, New York: American Book Company, 1930, pp. 140–147.

*GREVE, ANNA M.: "Soil: Its Sources and Uses," Columbus: American Education Press, 1935, 24 pp.

HODGE, CLIFTON F.: "Nature Study and Life," Boston: Ginn and Company, 1902, 495 pp.

OLIVER, EDWARD W.: "Landscaping the Small Home," New York: A. T. De La Mare Company, Inc., 1931, 146 pp.

EXPLORING A BROOK OR POND

Aims

Interest in water life. New avenues of satisfaction and education for summer-vacation hours.

Experience contributing to concepts of the interrelationship of living things and the persistence of types suited to their environments.

Suggestions

Let the children tell what plants and animals they have seen in or about the water. Along in May, when the water is beginning to teem with plant and animal life again, plan a trip to a small stream, pond, or shallow lake margin to discover what lives there.

As you approach the water, stop a few yards distant for quiet observation. Remain here for some time to discover what birds and other animals visit the place. Listen to the sounds, and observe the animals making them. Watch for animals appearing at the surface or making disturbances in the water.

Approach the water for closer observation. Discover what plants grow in the wet soil about it. Note whether any animals are to be found in this zone about the water.

Discover whether any animals are traveling over the surface of the water. Bend close, and watch the activities beneath the surface of the shallow water. Note the submerged plants, those which project above the water, those with roots in the soil and floating leaves, and the floating plants. Cut through a water plant, and note the air holes in the stem.

Drag some of the submerged vegetation out of the water, and study the animals that crawl out of the mass. If you have a water net or a strainer pan, collect animals from the open water and from the ooze at the bottom. If a stream is visited, turn over some rocks in the running water, and examine the forms clinging to them.

Talk over the different places in and about the water where different kinds of plants and animals can live. Discuss their ways and what they find to eat, giving the children interesting information about the water forms.

Observe the water plants and animals to discover how they are suited to life in the water. Travel along the margin of the pond and along the stream to discover whether there are different plant and animal communities. If some older boys are free to go along on the trip, get them to seine some of the deeper portions with a minnow net.

Bring some of the ooze, submerged vegetation, and water back in a bucket. After it has stood for a time, examine carefully for the smaller forms of life. Use a microscope if one is available.

Write or tell some of the affairs going on in the water communities. Read about water life.

Contributing Learnings

There is a busy community of living things in a pond or stream. Within the community there are many kinds of places to live, each with its dwellers.

The zone about a pond usually contains marsh marigolds or cowslips, swamp milkweeds, swamp grasses, sedges (mostly recognizable by their three-angled stems), and other plants. In the shallow water are likely to be sedges, cattails, and arrowheads. Where the water is deeper, the more conspicuous plants include pickerel weed (in the east), water lilies with their floating leaves, and the straight stems of the rushes.

Growing almost entirely in the water (submerged) are commonly pond weeds (the larger submerged plants), Elodea (Canadian waterweed), milfoil (Myriophyllum), and many kinds of algae. Duckweeds are tiny floating plants.

Water striders run about over the surface of the water without breaking through the surface film. Flocks of whirligig beetles spin about on the surface of the water.

Within the water are many insects, water fleas (crustaceans), leeches (bloodsuckers), worms, tadpoles, minnows and small fishes, crayfishes, turtles, and other animals. There are myriads of the water fleas and other tiny forms, a great many insects, and a few of the larger forms such as turtles. There is plenty of food for the host of small animals but only enough for a few larger ones. The smallest animals eat the plants; the larger animals feed on the smaller ones.

Many animals come to the water to feed or to spend part of their lives. Toads and frogs come to lay their eggs in the water.

Birds such as kingfishers, terns, swallows, herons, and bitterns come here to feed on the animal inhabitants.

Most plants could not grow here, as they cannot stand "wet feet" (lack of air in the soil). The water plants are all suited to water life. They have air passages in their stems. They are able to bend and can withstand being tossed about by the waves. The ropelike leaf stalks of water lilies allow the leaves to float though the water-level changes. Water plants can take up water through their skins, but land plants cannot. When brought out on the shore, the former soon dry out and shrivel. (There are many other characteristics fitting them for water life which young children cannot understand.)

The animals are also water experts. They are very good swimmers. Water beetles have oarlike legs. Fishes have broad tail fins for swimming and side and back fins for balancing. They are narrow and can slip through the water easily. Most of the water animals have gills for taking in air from the water and do not have to come to the surface to breathe. Turtles, however, are lung breathers and frequently poke their heads out of the water for air. Frogs and toads can breathe through their skins. Some water insects (water boatmen, for example) carry shiny bubbles of air held among the hairs on the body. The water plants are covered with oxygen bubbles which they give off and which help the animals to live.

Flowing streams contain more air than still pond water. This is one of the chief reasons why stream animals and pond animals are often different. More of the active animals which require a great deal of air live in streams. Animals with a low air requirement can live in ponds.

(The teacher will find the water forms pictured and discussed in some of the references cited. It is hardly feasible to list the information concerning the various species here.)

References

*Athey, Lillian Cox: "Along Nature's Trails," New York: American Book Company, 1936, pp. 48–64, 284–317.

Comstock, Anna Botsford: "Handbook of Nature Study," Ithaca, New York: Comstock Publishing Company, 1911, pp. 818–824.

**Cornell Rural School Leaflet*, Vol. 13, No. 4: The Nature Study of Streams and Ponds, Ithaca, New York: Cornell University, March, 1920.

**Cornell Rural School Leaflet*, Vol. 14, No. 2, Ithaca, New York: Cornell University, November, 1920.

Cornell Rural School Leaflet, Vol. 21, No. 1: Teachers' Number, Ithaca, New York: Cornell University, September, 1927.

**Cornell Rural School Leaflet*, Vol. 26, No. 4: The Marsh in Spring, Ithaca, New York: Cornell University, March, 1933.

*DOUGAN, LEWIS M.: "Stories of Outdoor Science," New York: Lyons and Carnahan, 1933, pp. 117–158.

DOWNING, ELLIOT R.: "Our Living World," Chicago: University of Chicago Press, 1924, pp. 1–56.

*FULLER, RAYMOND T.: "Along the Brook," New York: John Day Company, Inc., 1931, 81 pp.

MORGAN, ANN HAVEN: "Field Book of Ponds and Streams," New York: G. P. Putnam's Sons, 1930, 448 pp.

*PATCH, EDITH M.: "Holiday Pond," New York: The Macmillan Company, 1929, 124 pp.

*——— and HARRISON E. HOWE: "Nature and Science Readers," Book I: "Hunting," New York: The Macmillan Company, 1932, pp. 75–86.

*——— and ———: "Nature and Science Readers," Book II: "Outdoor Visits," New York: The Macmillan Company, 1932, pp. 171–174.

*PERSING, ELLIS C., and EDWARD E. WILDMAN: "Elementary Science by Grades," Book IV, New York: D. Appleton-Century Company, Inc., 1934, pp. 47–62.

SCHMUCKER, SAMUEL CHRISTIAN: "The Study of Nature," Philadelphia: J. B. Lippincott Company, 1928, pp. 136–155.

*TORELLE ELLEN: "Plant and Animal Children," Boston: D. C. Heath & Company, 1912, pp. 1–31.

TRACING THE STORY OF A STREAM VALLEY

Aims

A better concept that natural forces are constantly changing the surface of the earth. Stretch of the child's concept of time. Some understanding of the dependence of life upon environment.

Some realization of the need for erosion control.

An outdoor exploration interest.

Suggestions

If there is a stream valley near the school, ask the pupils to tell you anything they know about it. Arouse interest concerning its past and probable future. Add an observation of your own that might offer a clue, and propose to the children that together you try to trace the story of the valley.

Begin to assemble and record information concerning the valley, its sources, mouth, approximate length, depth, width, shape, whether straight or crooked, kind of material eroded, presence and extent of any flood plains, nature of deposits, evidences of erosion and landslides along the slopes, changes in the valley within the memory of parents and grandparents, etc.

Estimate the present rate of stream flow by tossing floating objects into the water and timing them for a distance as they float downstream. Measure the depth of the stream, or secure this information together with the average stream width, and calculate roughly the amount of water passing any point in a minute. Note whether the current is undercutting the bank, especially at the bends. After a heavy rain, collect water in gallon buckets from the stream. Gently pour off the water after the sediment has settled, and examine the material carried by the stream. Take the material to a place where you can weigh it on a fine scale. Let the children calculate, with whatever help is necessary, the amount of sediment carried past your location by the stream per minute and per year. Help the pupils to calculate the approximate amount of time that it has required to carry away the material and form the present valley if the stream has always carried the load that it does now. Consider that the water is not always roily, as it is after rains.

Observe the vegetation in the stream valley. Has it apparently been there for a long time? Dig in the soil on one of the flood plains. Is it rather uniform in color and texture, as if recently formed, or does it have a darker humus layer at the surface the result of the partial decay of plant and animal remains over a long period of time?

Note whether there are many larger stones in the stream bed than the present volume of water and speed of the current would carry. Has the stream cut down to solid rock? Is the rock in layers?

Examine the walls of the valley. Are they vegetated or kept bare by rapid erosion? Have any trees or other plants fallen or been undercut? Are gullies forming in the bluff? Is the upland grassed, forested, or otherwise resistant to erosion?

Examine any cultivated fields that slope toward the valley. Are there gullies in the fields? Is the surface soil dark and full of humus in these fields, or has the topsoil been carried away by sheet erosion, leaving the lighter colored clay or sand exposed?

Let the pupils discuss all of the data and their probable significances. They might try to decide what made the valley, whether it is more than a few years old, whether it was formed since the glacier and has cut its way through the loose glacial drift, the significance with reference to age and past history if the channel is cut in stratified or unstratified rock, whether the stream was once larger, whether it has changed its course, whether the valley is increasing in size, the ultimate future of the region, from how great an area its sediment is being collected, the need for erosion control, and the influence of the stream valley on the local history and the lives of the people at present.

Contributing Learnings

Part of the rain goes into the ground. Some of it flows away toward lower levels owing to the pull of gravity. The flowing water carries soil in suspension. Swift-flowing water erodes more soil and is able to carry coarser material in suspension.

The sheet of water flowing down cultivated and unvegetated slopes carries away an enormous amount of the rich topsoil which it has required centuries of combined plant, animal, weathering, and chemical action to form. Millions of acres of sloping land have been made poor in this way until, with all our improved varieties, fertilizers, and better farming methods, we cannot

grow so much on an acre of land, on the average, as could our forefathers.

Very little soil washes away from slopes kept in grass or returned to meadow every few years. By plowing around the slopes instead of up- and downhill and by leaving unplowed strips at intervals, we can prevent most of the erosion.

Large amounts of water flowing in one place soon cut a small ditch or gully which grows, in time, to form a valley. The running water carries away soil and plants. It can also move stones by rolling them along the bottom. When the ice breaks up in the spring, some material is carried away frozen in the floating blocks of ice.

Some of the water that soaks into the ground appears again as springs along the valley and joins the stream. These springs keep the streams flowing between periods of rain.

Most of the erosion takes place following very heavy rains. Otherwise, the streams are usually fairly clear, although they always carry some fine sediment.

Young valleys tend to be V-shaped; old ones, broadly U-shaped. Valleys are constantly changing. New gullies form at the source and along the sides and eat their way back into the upland. Undercutting, surface washing, and landslides broaden the valley. The stream cuts deeper. It also erodes away its banks at the turn, widening the channel. At the same time it deposits material where the current is sluggish, forming flood plains and bars.

Most of our stream valleys in the glaciated part of the country have developed in the loose drift deposited by the glaciers. Erosion has taken place much more rapidly than it could have done in solid rock. For a time following the glaciers, there probably was much more water, and erosion doubtless took place more rapidly. Some of the streams have cut down through the glacial drift to stratified rock such as limestone and sandstone. Since stratified rock was formed under water, the region must have had a very long history and many experiences before the glaciers came. Valleys cut deeply in hard igneous rock are very old.

Streams carry away a great deal of the soil and surface material of the earth, depositing it in the ocean and large lakes. Streams eat back into the uplands, cutting them into ridges which eventually wear down. The streams erode their way back to small lakes and drain them. The streams finally wear away the uplands, thereby lowering the level of the land. All of this

requires a very long time, but it goes on steadily. In the meantime, new uplands may be formed by upheavals in the earth.

We can influence the rate of valley development by controlling stream flow with dams and by preventing erosion through suitable plantings and methods of cultivation.

Stream valleys cause loss of life and property in floods; afford water power; ruin soils of the uplands and eventually level the land; give us inland water transportation, afford routes through rough regions for roads and railroads, afford recreation in swimming, fishing, etc.; are sources of water supplies; make possible forested areas in treeless regions; offer fertile well-watered flood plains for agriculture; make difficult problems in road and fence building; and influence our lives in countless other ways.

References

*BEAUCHAMP, WILBUR L., HARRIET M. FOGG, GERTRUDE CRAMPTON, and WILLIAM S. GRAY: "Science Stories," Book III, Chicago: Scott, Foresman & Company, 1936, pp. 144–193.

**Cornell Rural School Leaflet*, Vol. 24, No. 3: Earth Forms, Ithaca, New York: Cornell University, January, 1931.

*CRAIG, GERALD S., and SARA E. BALDWIN: "Pathways in Science," Book II: "Out-of-doors," Boston: Ginn and Company, 1932, pp. 180–186.

*——— and BEATRICE DAVIS HURLEY: "Pathways in Science," Book IV: "The Earth and Living Things," Boston: Ginn and Company, 1932, pp. 66–82.

*——— and GOLDIE M. JOHNSON: "Pathways in Science," Book VI: "Our Earth and Its Story," Boston: Ginn and Company, 1932, pp. 81–109.

*DOUGAN, LEWIS M.: "Stories of Outdoor Science," New York: Lyons and Carnahan, 1933, pp. 71–113.

Textbooks of physiography.

WASHBURNE, CARLETON, and HELUIZ WASHBURNE: "The Story of Earth and Sky," New York: D. Appleton-Century Company, Inc., 1933, pp. 13–20.

MAKING A STUDY OF THE PRINCIPLES EMPLOYED IN A LOCAL INDUSTRY

Aims

Interest in the home community and its activities.

Appreciation of the importance of machines and of the role of labor in making possible enriched existence.

Realization that the development of industry is founded on the discoveries of science.

Suggestions

Children in the intermediate grades are able to make a very interesting study of local industries. In most localities outside the largest industrial cities, there are one or more industries which are the center of much of the activity of the community. Examples of such industries are mining, manufacturing, the stone industry, commercial fishing, truck gardening, and grain farming. In rural communities the local dairy may be studied.

Go on field trips to study all processes in the industry. The management is usually pleased with any show of interest in the local industry and is glad to cooperate.

Secure samples of the materials used and of the product in all stages of production. Get pictures of the operations.

Ask questions as to the reasons for the various procedures. Study the machinery and the process, to discover the principles employed. Find the uses made of the product and where the output goes.

Write an account of the study, explaining the processes employed in the industry and the service it renders, and submit it to the local paper for publication.

Encourage pupils to visit other industries during visits to other communities.

Contributing Learnings

(The class should work out a definite statement of all knowledge gained through the study. The learnings will vary with the industries studied and for this reason cannot be stated here.)

References

GIBSON, CHARLES R.: "The Romance of Modern Manufacture," London: Seeley, Service & Company, 1930, 320 pp.

*GRUENING, MARTHA: "The Story of Mining," New York: Harper & Brothers, 1931, 163 pp.

*TAPPAN, EVA MARCH: "Makers of Many Things," Boston: Houghton Mifflin Company, 1929, 119 pp.

HOLDING A SCIENCE EXHIBIT

Aims

Satisfaction in achievement. Stimulus to carry on activities during the summer vacation. Review of year's work.

Suggestions

The science exhibit consists of the tangible evidences and records of the projects carried out during the year. If they have been preserved, no new projects are needed to make a splendid display. The achievements in some of the undertakings, such as the museum, are naturally more tangible and suitable for exhibit than those of other equally worth-while activities. However, almost all of them have resulted in some interesting evidences.

Bring forth the projects and everything capable of recalling to the children and to the parents the science activities of the year. The exhibit thus serves as a review of the year's work.

Send a special invitation to all parents and to the pupils and teachers of other grades. Neighboring schools may be invited. Let the children have the educational experience of entertaining visitors and explaining their own activities. Post a list of activities carried on during the year.

Contributing Learnings

(The contributing learnings and outcomes for which the activities serve as points of departure have been stated in connection with the activities. It is well to review and assemble them.)

INDEX TO PART I

See also Index to Part II

INDEX TO PART II

See also Index to Part I